Draft Technical Guidance for Determining the Presence of Polychlorinated Biphenyls (PCBs) at Regulated Concentrations on Vessels (Ships) to be Reflagged

U.S. Environmental Protection Agency

Office of Pollution Prevention and Toxics (OPPT) / National Program Chemicals Division
and
Office of Resource Conservation and Recovery (ORCR) / Materials Recovery and Waste Management Division

Table of Contents

I. Objective

The United States Environmental Protection Agency's (EPA's) Office of Resource Conservation and Recovery (ORCR) and Office of Pollution Prevention and Toxics (OPPT) have prepared this technical guidance as a resource to assist ship owners in identifying regulated levels of polychlorinated biphenyls (PCBs) [*i.e.* greater than or equal to (≥) 50 parts per million (ppm)] in shipboard materials before their ships are sold to a non-U.S. Citizen or transferred to a foreign flag registry, prior to export from the U.S. Ultimately, ship owners are responsible for complying with the Toxic Substances Control Act (TSCA) and EPA's PCB regulations that prohibit export of material containing regulated levels of PCBs. In this technical guidance, the EPA presents statistically-based sampling approaches that can be used, as well as an approach for using ship records and documentation, to potentially determine the presence of regulated levels of PCBs on a vessel to be reflagged. This draft document primarily addresses the presence of regulated levels of PCBs in non-liquid materials on board a vessel intended for export. It is not intended to fully address remediation or cleanup of contamination from spills or releases of liquid PCBs, or specific liquid PCB concerns. For remediation or cleanup of contamination from spills or releases of liquid PCBs, please refer to the following:

- PCB regulations found at Title 40 of the Code of Federal Regulations (CFR) Part 761
- Various spill cleanup guidance documents and Q & A material found on the EPA PCB website

References for the above material can be found in Section VI below.

This is a draft technical guidance document, not a regulation or policy document. This draft guidance document does not impose any requirements or obligations on EPA or the regulated community, nor does it release any party from liability for any violation of TSCA or its implementing regulations. This draft guidance document presents current technical information and suggestions of ORCR and OPPT, based on our current understanding of the presence of PCBs in shipboard materials. This is information that a ship owner may use to conduct an assessment of whether his or her ship contains regulated levels of PCBs when requesting a transfer of a U.S. flagged ship to a foreign registry. Completing a guidance-based assessment, such as that presented in this draft guidance, does not guarantee that regulated levels of PCBs will not be found on the ship at a later date, nor does it create a defense against a violation under TSCA if that occurs.

The terms "vessel" and "ship" are used interchangeably in this document. However, please note that both terms refer to the statutory definition of a "vessel," found at 1 U.S.C. §3 which is an inclusive term for ships, small craft, and boats.

II. Overview

Background

PCBs belong to a broad family of man-made organic chemicals known as chlorinated hydrocarbons. PCBs have a range of toxicity and vary in consistency from thin, light-colored liquids to yellow or black waxy solids. Due to their non-flammability, chemical stability, high boiling point and electrical insulating properties, PCBs were used in hundreds of industrial and commercial applications including electrical, heat transfer and hydraulic equipment; as plasticizers in paints, plastics and rubber products;

and in many other industrial applications. Exposure to PCBs can cause a variety of adverse health effects in animals and humans. In animal studies, PCBs have been shown to cause cancer as well as serious non-cancer health effects. In humans, PCBs are potentially cancer-causing and can cause other non-cancer effects including immune system suppression, liver damage, endocrine disruption, and damage to the reproductive and nervous systems (U.S. EPA, Retrieved December 2011, from http://www.epa.gov/pcbsincaulk/guide/guide-sect1.htm).

PCB Laws and Regulations

The Toxic Substances Control Act (TSCA), enacted in 1976, generally prohibits the manufacture, processing, distribution in commerce, and use of PCBs; authorizes EPA to create limited exceptions to these prohibitions; and requires EPA to control the marking and disposal of PCBs. Pursuant to TSCA section 6(e), EPA has promulgated comprehensive regulations to manage PCB activities in 40 CFR Part 761. These regulations implement the statutory prohibitions, establish limited authorizations for use of PCBs, provide definitions for regulatory terms, establish storage and disposal requirements, and establish various reporting and recordkeeping requirements for PCBs.

This draft technical guidance focuses on providing approaches that a ship owner may take in an effort to comply with the PCB export regulations as part of an application to re-flag a vessel so it can be exported from the U.S. Generally, if a vessel contains material and/or equipment with PCBs at or above 50 ppm (regulated levels of PCBs), then export of that vessel for any purpose (such as scrapping) would violate the regulations and TSCA.[1] Such PCB regulated materials must be remediated or removed from the vessel for disposal in accordance with the PCB regulations before the vessel may be exported from the U.S. The EPA Administrator has authority to grant an exemption by a regulation [see TSCA sec. 6(e)(3)], but this process has generally been regarded as requiring too much time and resources to be a realistic approach for the export of individual vessels containing PCBs.

The PCB regulations do not require the submittal of sampling plans and analytical data to re-flag or export a vessel. However, because the Maritime Administration (MarAd) requires a vessel owner seeking to re-flag a vessel for export to certify that the export would not include materials containing regulated levels of PCBs, this type of sampling plan and data is extremely important and could be used to support such a certification. Also, this information might be useful during an EPA inspection.

Definitions

All the terms and abbreviations used in this technical guidance shall have the meanings as defined in 40 CFR 761.3 unless the term is defined differently below for the purposes of this document.

Census: When every item in the sampling frame is selected for testing, then the testing group is a census and not a sample.

Composite Sample: A sample consisting of combining two or more samples of like material.

Conclusion Probability: The probability that the sampling plan will detect PCBs at regulated levels.

---

[1] In general, U.S. flagged vessels are re-flagged to another country prior to export, regardless of whether the vessel is to be exported for disposal or for continued use.

Conclusion Proportion: The underlying proportion of items that could contain regulated levels of PCBs. Used in conjunction with Conclusion Probability to determine the number of samples needed to meet the following desired conclusion: "The probability that this sampling plan would detect PCBs at regulated levels is at least (value for Conclusion Probability) if the true underlying proportion of materials containing them were greater than or equal to (value for Conclusion Proportion).

Inaccessible Item: Item that does not need to be sampled due to inaccessible or unsafe conditions. These items are still included in both the material category population and sampling frame.

Material category: Defined from List II.A below.

Material containing regulated levels of PCBs: Material with a concentration of total PCBs ≥ 50 parts per million (ppm).

Material subgroup (logical subgroup): Logical groupings of items in a category that all share the same attribute(s), which allows the ship owner to make the assumption that all the items in the subgroup contain the same concentrations of PCBs.

Material that does not contain regulated levels of PCBs: Material with a concentration of total PCBs < 50 ppm, but not necessarily 0 ppm.

Omitted Item: An item that is not sampled because, it is shown through documentation to not contain regulated levels of PCBs. These items are not included in the sampling frame, but are included in the material category population on the ship being sampled.

Physical sample (for PCB testing): An item from the statistical sample, or a portion of the item. In some cases, the entire item will be used in the analytical PCB testing process and in other cases a portion of that item will be removed for testing. There is potential for ambiguity here. The statistical sample is the list of items to be tested; a physical sample is the portion of a single item that will be chemically tested for PCBs.

Population (Inventory): All of the items on a vessel that share a characteristic of interest and that make up a material category, e.g., the population of fluorescent light ballasts is the set of all such ballasts on the vessel. In this document, we refer to categories of materials that may contain PCBs. The population is the group or set of items about which the ship owner is trying to draw a conclusion regarding the likelihood that PCBs are present at regulated levels.

Sampling event: The process of collecting a physical sample.

Sampling frame: An enumerated list of items in a population that is eligible to be included in a statistical sample. Sometimes the sampling frame lists the entire population; in this document, a sampling frame for a category of materials will list every item in that category that might contain PCBs at a regulated level. It will exclude items that are documented to not contain PCBs at regulated levels, and it may exclude items that may be assumed to not contain PCBs at regulated levels because of their documented time and location of manufacture or installation. Note: The sampling frame is not related to the frames of a ship which are the transverse ribs connected to the keel.

Sampling plan: A list of categories of materials to be tested either via a census or targeted sampling, along with a sample size for each category (possibly different from category to category).

Statistical sample: A randomly selected subset of items from a sampling frame.

<u>Targeted sampling:</u> An approach to sampling used in this technical guidance document to target items for sampling that cannot be ruled out by documentation or historical records to not contain regulated levels of PCBs.

<u>Test result:</u> PCB concentration in parts per million (ppm); a result ≥ 50 ppm may sometimes be called a positive result, meaning that there is a positive indication of PCBs at the Act (TSCA) regulated concentration or level; a result < 50 ppm may sometimes be called a negative result, meaning that the test failed to indicate that PCBs are present in the item at a regulated concentration or level.

<u>Vessel (Ship):</u> Inclusive term for a ship, small craft, or boat. *Vessel* and *ship* are used interchangeably in this document.

Identification of PCB-containing Materials and Potential On-board Locations

Although no longer commercially produced in the United States, PCBs are most likely present in U.S. manufactured vessels constructed before TSCA came into effect—that is, before 1979. Even vessels constructed after that date may have PCBs, for example, due to replacement parts installed in foreign ports of countries where PCB manufacture or distribution was not prohibited. For such older vessels, PCBs may be found in both the solid (waxy) and liquid (oily) forms in equipment and materials onboard ships. See List II.A. below for a list of shipboard equipment and material that may contain PCBs in concentrations of ≥ 50 ppm.

Components containing PCBs may be found throughout a ship. In addition, PCBs may be found in a variety of shipboard materials, but the location and concentration can vary from item to item and within material categories. PCB-containing materials also are likely to vary from ship to ship, and even ships in the same class can contain differing types and amounts of PCB-containing materials. While these materials may be found throughout a ship, several areas on ships may have an increased likelihood of containing PCB-containing materials: areas or rooms subject to high heat or fire situations, such as boiler rooms, engine rooms, electrical/radio rooms, weapons storage areas, or areas with hydraulic equipment. Be aware that these pieces of equipment or systems are vulnerable to leaks and spills, which could leave residues behind and contaminate porous materials (e.g., carpet, wood, rubber/plastic mats, paint) (US EPA, 2006, *National Guidance: Best Management Practice for Preparing Vessels Intended to Create Artificial Reefs*, p.36).

Approaches for Determining Presence of Regulated Levels of PCBs in/on Shipboard Materials

All of the approaches in this draft technical guidance document focus on evaluating the ship as a whole, or evaluating categories of shipboard materials individually and then combining the data from the individual material categories to make an overall assessment of the presence of regulated levels of PCBs on the ship as a whole. For the purposes of this draft document, all potential sources of PCBs have been put into the following categories:

<u>List II.A. Categories of Shipboard Material that May Contain Regulated Levels of PCBs</u>

<u>Categories that could contain non-liquid (solid) PCBs</u>
- Paint (e.g., oil-based or aluminized)
- Non-conducting materials in electrical cables (such as plastic and rubber)
- Rubber gaskets
- Felt gaskets

- Insulation material, including fiberglass, felt, foam, and cork (not including electrical cable insulation, but including sound deadening felt)
- Adhesives and tapes
- Caulking/Grouting (including putty, silicon, and bitumen)
- Rubber isolation mounts, foundation mounts, and pipe hangers
- Plastic applications (including vinyl and PVC)
- Other materials on the vessel not explicitly listed here, but that may be suspected to contain PCBs at regulated concentrations because of their form or function or year and place of manufacture and installation (for example, floor or ceiling tiles)

<u>*Categories that could contain liquid PCBs*:*[2]</u>

- Oils, greases, and lubricants, including drained electrical equipment:
    - Oil used in electrical equipment such as transformers, rectifiers, motors, anchor windlasses, hydraulic systems, vacuum pumps, and leaks and spills from such items
    - Cutting oil
    - Heat transfer fluids
    - Air compressor lubricants

<u>*Categories that could contain either liquid or solid PCBs*</u>

- Spills and Surface Contamination (wipes)*
- Fluorescent Light Ballasts*
- Electronic equipment (including switchboards, consoles, voltage regulators, switches, reclosers, bushings, and electromagnets)*

Please note that the ship owner has the option to create different categories, if there is a more appropriate categorization for their vessel. However, EPA urges ship owners to keep distinct categories separate, since, for example, PCBs in paint and PCBs in electrical cable would most likely not be related either from a history of incorporation into the vessel, in the function of the material, or in the type of PCBs utilized.

** Liquids, spills and surface contamination, light ballasts, and electrical equipment are each handled uniquely (see the self-titled Parts in this Section below)*

The process of evaluating a vessel for the presence of PCBs begins with a review of historical records related to the construction and maintenance of the vessel and type of vessel. In some cases, the records alone or the records and related documents will facilitate a confident conclusion that the vessel is unlikely to contain regulated levels of PCBs. In other cases, the records will be ambiguous or incomplete, or they will indicate that the presence of PCBs is possible or even likely. In the latter case, the ship owner will need to decide how best to proceed. For example, they could choose to collect samples from some or all of the potentially PCB-containing materials on the vessel and have them chemically tested in order to accurately determine the presence/absence of regulated PCBs on the vessel. On the other hand, the ship owner could also choose to simply remove the potentially PCB-containing materials from the vessel and dispose of them as TSCA regulated materials (materials containing regulated levels of PCBs). An approach to demonstrate that regulated levels of PCBs are unlikely to be

---

[2] Even though these systems may have replaced the PCB-containing oils and other fluids with non-PCB-containing oils and fluids, these oils and fluids may still contain regulated levels of PCBs.

present on a vessel should address all categories of materials that may contain regulated levels of PCBs, or have been known to contain PCBs on previous assessments. The approach described in this document considers each category separately and combines the evidence for all categories to draw a final conclusion as to whether the ship is likely to contain regulated levels of PCBs.

This document provides technical guidance on how to determine which material categories need to be tested and on selecting the number of items of each material category to test in order to conclude that the vessel is unlikely to contain materials with PCBs at concentrations ≥ 50 ppm.[3] The three approaches outlined are: (1) use of historical records; (2) non-targeted sampling, and (3) targeted sampling.

Use of Historical Records
The presence of PCBs in shipboard material could potentially be determined through documentation, such as records related to the construction and maintenance of the vessel. The ship owner may have sufficient documentation to prove that a specific material category or an entire vessel itself does not contain regulated levels of PCBs. For example, a ship owner may have documentation that a ship was constructed in the United States with only materials manufactured after TSCA was in effect. See Section IV of this document for more details on this non-sampling approach.

Non-Targeted Sampling
In some cases, the ship owner may not have any records which could be used to exclude certain material categories from testing. In these cases, EPA recommends compiling an inventory of each material category listed in List II.A., or any other material category that the ship owner believes may contain PCBs at regulated levels and randomly sampling a certain number of items within the inventory of each material category to reach a specific statistical level of confidence that the vessel does not contain regulated levels of PCBs. Section V of this document details EPA's recommended sampling procedures and assessment of sampling results; examples of the statistical analysis are also provided in Appendix II of this document.

Targeted Sampling
The targeted sampling approach uses historical records to determine items, materials, areas, and/or parts of the vessel that do not contain PCBs. Sampling would then be performed on the remaining items on the vessel. If documentation is used to determine the presence of regulated levels of PCBs for an entire category or one or more items of a category, then it is considered targeted sampling. A targeted sampling approach may also be applied to support the conclusions or findings, after a review of historical construction and maintenance records. For example, records may indicate that all of the older electrical cables in a vessel may have been replaced with more modern PCB-free electrical cables. In this case, the category for electrical cable material does not have to be sampled. Alternatively, if only a portion of the electrical wiring was replaced, then the ship owner could exclude the newer wiring from the sampling frame for the electrical cable material category which will impact the number of samples recommended for the remainder of the electrical cables.

[3] As noted above, a ship owner could decide to simply remove the potentially PCB-containing materials from the vessel rather than conducting testing and dispose of them as TSCA regulated materials. In this case, all materials within a particular material category should be removed from the vessel unless the ship owner has information that a particular material(s) within a particular material category does not contain regulated levels of PCBs.

These sampling approaches are not designed to prove that there is absolutely no material containing $\geq$50 ppm PCBs on a vessel, as this would require literally testing everything on the ship.

Whichever approach is used, it is important to note that TSCA is a strict liability statute. In other words, regardless of the approach used to determine the presence of regulated levels of PCBs on a vessel, if the vessel is exported with even one piece or component of the ship being greater than or equal to 50 ppm, the ship owner is in violation of TSCA.

In this regard, if the "non-targeted sampling" or "targeted sampling" approach is followed, there is no required or recommended statistical goal set by EPA. Ship owners should set their conclusion probability and conclusion proportion at their own risk. Higher values of conclusion probability and lower values of conclusion proportion will result in less risk that the result for determining the presence of regulated PCBs is incorrect. As aforementioned, regardless of the level of testing, TSCA is a strict liability statute. The conclusion probabilities used in the example in the appendices are 90%, 95%, and 99%, so the conclusion proportions used are 1%, 5%, and 10%.

Liquid PCBs

Due to the frequency with which high concentrations of liquid PCBs were used in electrical equipment and other applications, EPA recommends that the ship owner consider all liquid applications to be regulated. Unless a liquid's PCB status is known from some type of documentation (e.g., label or nameplate information, manufacturer's literature – including documented communications with the manufacturer, etc.) to not contain regulated levels of PCBs, then EPA recommends the liquid be removed from the vessel or undergo chemical analysis to determine the PCB concentration of the liquid.

EPA does not anticipate that the chemical analysis and/or removal of all liquids will affect a vessel headed for disposal under the power or tow of another vessel. However, if the vessel needs to continue operating prior to reaching its final destination or just continue operating in general, then removing all the liquids could render the ship inoperable. In this case, the ship owner should choose between the cost of removing all the liquids and equipment containing the liquids against the cost of sampling all liquid applications and removing/decontaminating the items that test positive for regulated levels of PCBs.

It should be assumed that drained PCB Articles (e.g., transformers and pipes) have surface residue with the same concentration as the liquid PCBs in the PCB Article. If the concentration of the liquid PCBs is not known, the ship owner may choose to remove the PCB Article, decontaminate the PCB Article, and/or sample the PCB Article through wipe sampling for the presence of regulated levels of PCBs.

Liquid, Wipe, and PCB Article Regulations

- Regulations for decontaminating a non-porous surface, including scrap metal from disassembled electrical equipment, can be found in 40 CFR 761.79. 40 CFR 761.79 (b) & (c) detail the standards and performance based decontamination procedures for non-porous surfaces. To use decontamination methods other than those explicitly listed in the regulations, an approval from EPA is required as described in 40 CFR 761.79(h).
- Regulations for disposal of PCB Articles can be found in 40 CFR 761.60(b).
- Regulations for disposal of liquid PCBs can be found in 40 CFR 761.60(a).
- Regulations for wipe sampling of non-porous surfaces can be found in 40 CFR 761.123.

Electrical Equipment

Items, such as switchboards, consoles, radio equipment, voltage regulators, switches, re-closers, bushings, and electromagnets may have solid PCBs in the insulation of the cabling inside of them; liquid PCBs in capacitors may also be inside these items.

Due to the high probability of liquid PCBs being found in electrical equipment, the EPA recommends using the same approach with electrical equipment containing liquid PCBs as recommended for liquid PCBs in the preceding section --- unless the electrical equipment's PCB status is known from documentation to not contain regulated levels of PCBs, then EPA recommends the item be removed from the vessel or undergo chemical analysis to determine the PCB concentrations of the materials inside the item (e.g., capacitors, cables). In general, small capacitors manufactured prior to 1978 are likely to contain regulated levels of PCBs.

However, EPA anticipates that the ship owner may have access to some type of documentation (e.g., label or nameplate information, manufacturer's literature derived from the make and model number on the item, etc.) for some of the electrical equipment on the vessel. In these cases, the ship owner could use this documentation to salvage the electrical equipment that does not contain regulated levels of PCBs. The vessel owner should reference 40 CFR 761.2 for regulations on making assumptions about electrical equipment only for continued use (not for disposal). Please note that PCBs must be disposed of at their actual concentration at the time they are removed from service – the TSCA rules do not provide any assumptions for disposal. However, if ship owners choose not to sample electrical equipment manufactured prior to July 2, 1979, then it should be assumed that the equipment contains PCBs in regulated quantities.

Please note that some liquid-filled electrical equipment (e.g., transformers) may fall under a continued use authorization (40 CFR parts 761.20 and 761.30), and thus, may not need to be removed from the vessel, even if the item contains regulated levels of PCBs. However, the continued use authorizations do not apply to an export for scrapping/disposal. Instead, these authorizations apply to the export of a vessel that will continue to be used as a vessel.

Fluorescent Light Ballasts

If a light ballast does contain PCBs, they may be found inside the small capacitor or in the surrounding potting material. There would be approximately 1 to 1½ ounces of PCBs in the capacitor itself and smaller volumes in the potting compound, which is a black, tar-like substance that encapsulates the internal electrical components. Leaks of PCBs from ballasts typically take two forms: a clear to yellow oily liquid, the PCB oil itself, or the liquefied potting material. If the ballast fails or overheats, the capacitor may break open and both its oil and the potting material may be released to or from the fixture. The capacitor does not always leak when the ballast fails, but measures should be taken to limit or avoid personal exposure in all cases, because leaks may occur for any of a variety of reasons. (U.S. EPA, Retrieved December 2012, from http://www.epa.gov/waste/hazard/tsd/pcbs/pubs/ballasts.htm).

All fluorescent light ballasts should be visually inspected. Sampling the liquids in the capacitor is not recommended due to risk of unnecessary human exposure. To avoid that unnecessary risk, older or foreign-made fluorescent light ballasts should be properly disposed and replaced. The following points may be of use in determining if the ship's ballasts contain regulated levels of PCBs:

- Ballasts manufactured through 1979 may contain PCBs.

- Ballasts manufactured between 1979 and 1998 that do not contain PCBs should be labeled "**No PCBs**." If a ballast does not have this label, it is best to *assume* it contains PCBs.

If the ballasts are *not* marked with the statement "**No PCBs**" or the marking is inconclusive, the ship owner has two options:

1. Assume that the ballasts contain regulated levels of PCBs and remove the ballasts from the ship (properly disposing of them), or
2. Contact the manufacturer to determine whether the ballasts contain PCBs. If the manufacturer is not sure whether the ballasts contain PCBs, assume that they do and remove the ballasts from the ship (properly disposing of them), or

Additional Fluorescent Light Ballast References

- For general information on PCBs in light ballasts, see EPA site: http://www.epa.gov/waste/hazard/tsd/pcbs/pubs/ballasts.htm

- See the following chart for disposal options for light ballasts: http://www.epa.gov/waste/hazard/tsd/pcbs/pubs/ballastchart.pdf

Spills and Surface Contamination

Under the TSCA regulations, a spill of liquids containing PCBs $\geq$ 50 ppm is considered illegal disposal of PCBs. Material(s) contaminated by such a spill must be cleaned or removed and disposed of. For cleanup of spills within 72 hours of the time of the spill, the ship owner can use EPA's PCB spill cleanup policy in 40 CFR Part 761, Subpart G. For other spills, the ship owner should follow the regulations under 40 CFR 761.61 to properly cleanup the PCB remediation waste. The ship owner may also follow the decontamination regulations under 40 CFR 761.79.

EPA recommends that all spills, residues, and stains in rooms containing or having previously contained any liquid application of PCBs (e.g., boiler rooms, engine rooms, and control rooms) be tested and/or cleaned. Cleaning a spill, residue, or stain can include removing from the vessel and properly disposing of the item(s) on which the spill, residue, or stain exists. As for the remaining areas around the vessel containing standing liquids, sludges, or stains, EPA recommends that the ship owner consider taking additional samples of such liquids, sludges, and/or stains in a manner that is consistent with the potential for such areas to contain regulated levels of PCBs.

There may be a number of areas on the vessel with standing water or small pools of rain and/or sea water that do not appear to contain oils which could contain PCBs. Ship owners should consider the potential for such water to have been in contact with or impacted by materials containing PCBs when determining whether to test these areas for PCBs.

Please note that wipe sampling is not appropriate for measuring PCBs on porous surfaces. Paint is considered a porous surface.

Additional Spill Cleanup References

- See Site Revitalization Guidance for Spill Cleanups: http://www.epa.gov/waste/hazard/tsd/pcbs/pubs/pcb-guid3-06.pdf

III. Sampling versus Non-Sampling: Guidelines for Selecting an Approach

General Guidelines

There are several possible indicators to document the likelihood of a vessel not containing PCBs at regulated concentrations (i.e., ≥ 50 ppm). A ship owner could choose not to sample and could solely use historical records, if there is documentation supporting any of the following scenarios:

- Vessel was built and serviced only in places that did not use PCBs at the time (e.g., after TSCA was in effect for U.S.-built ships).
- Vessel has had all materials that might contain PCBs removed.
- Vessel has had all materials that might contain PCBs replaced with materials certified to not contain PCBs.

This draft technical guidance document identifies several categories of materials (see List II.A.) that might be found on a vessel that contain PCBs at concentrations ≥ 50 ppm. Each material category should be considered separately. A ship owner could limit the total sampling for an individual material category if there is documentation to support any of the following scenarios:

- Vessel contains no materials in that category, thus the entire category can be excluded from sampling.
- All materials in that category can be documented as not having regulated concentrations of PCBs, either with documents that address PCBs directly or with documents that show that the place and date of their manufacture makes it unlikely that they would have regulated concentrations of PCBs, thus the entire category can be omitted from sampling. Please note that some items in a category may fall under a continued use authorization (40 CFR 761.30), which would permit continued use, but not export for disposal, of qualified items with regulated levels of PCBs.
- Some materials in that category can be documented as not having regulated concentrations, which would mean those items would be omitted from the sampling frame. This could decrease the number of samples needed to reach a certain conclusion probability. Also note that the ship owner could have documentation that certain locations on a vessel may not have regulated levels of PCBs. For example, if the bridge was completely renovated, the ship owner may have documentation to omit all the items (from various material categories) from the sampling frame from that area of the vessel.

If there is no documentation to omit any items from testing, then the PCB testing of the vessel is said to be "*non-targeted*." If any items in any material category or an entire material category can be omitted from testing, then the PCB testing of the vessel is said to be "*targeted*."

Cost Considerations

<u>*Preliminary Testing: Screening Level Assessment*</u>

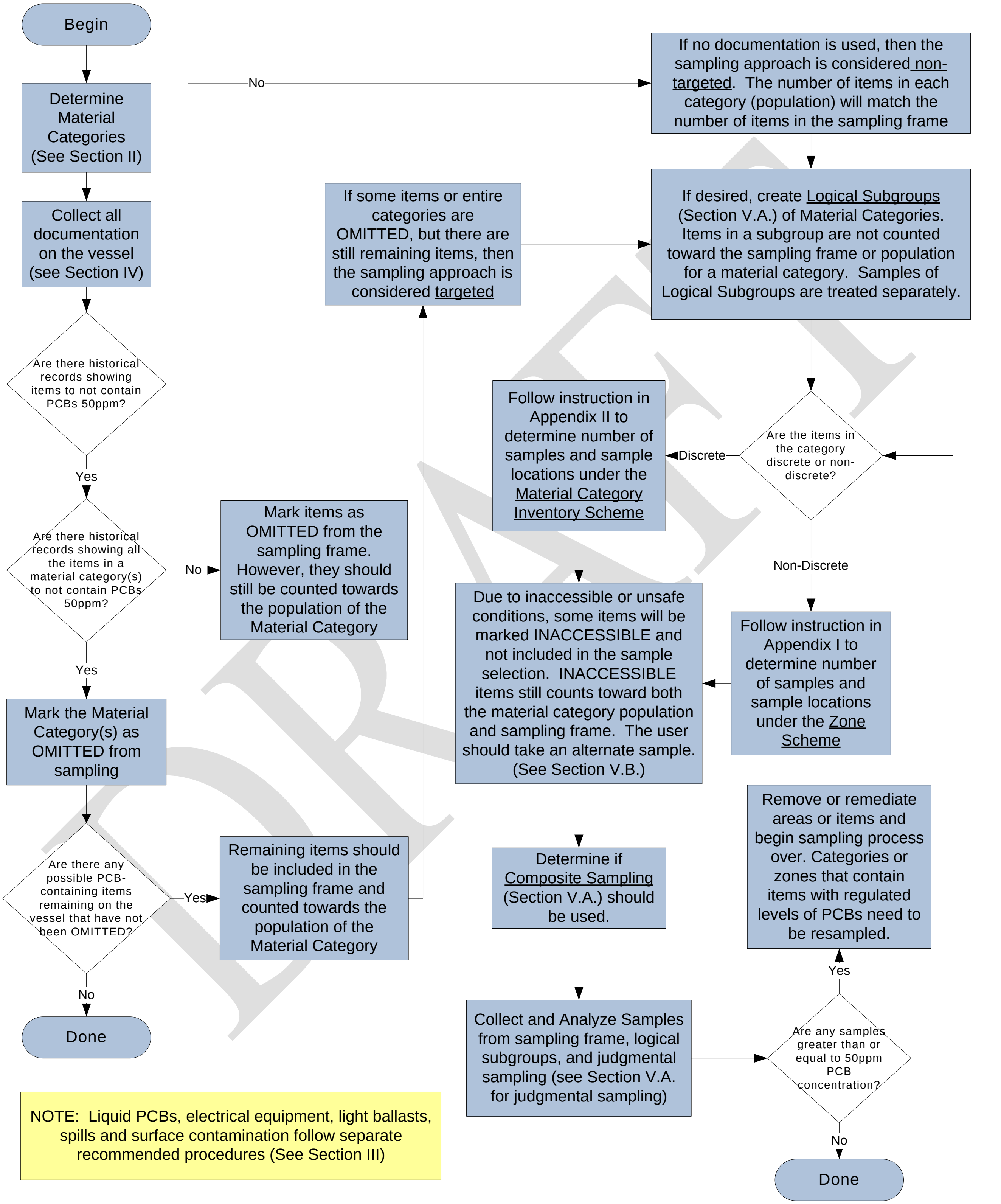
If it is likely that some categories of materials on the vessel contain PCBs at ≥ 50 ppm, then it might be cost effective to remove or remediate those materials proactively, or to chemically test a small number of those materials to verify that high concentrations of PCBs (PCBs at ≥ 50 ppm; regulated levels of PCBs) are present. A small number of tests can be conducted using non-random selection of materials that are thought likely to contain PCBs, or the small number of preliminary tests can be conducted on materials that are randomly selected, as described in Section V, Part A "Sampling in Stages" and Appendix II. If the tests come back with high PCB concentrations, then remediation can begin without the cost or delay of further testing. If the test results come back contrary to expectations with concentrations < 50 ppm, then the randomly selected materials can be considered to be part of the larger sampling effort needed to be sampled in order to provide a high degree of confidence that PCBs are unlikely to be present in concentrations ≥ 50 ppm.

Sampling v. Gathering Documentation

Chemical testing for PCBs can be very costly. If several categories of materials are tested and the ship owner wants results that provide a high degree of confidence about the low likelihood of the presence of regulated levels of PCB, then many samples will be required. The number of samples required can be reduced if some categories can be omitted from testing by virtue of adequate documentation or proactive remediation.

There are costs associated with chemical testing, and there are costs associated with assembling documentation. If the costs for sampling are high, it might be more cost-effective to assemble available documentation, when it is available, as an alternative to chemical testing. The ship owner can use available information and the technical guidance in this document to select a balance of documentation and chemical testing that yields a cost effective approach to concluding whether PCBs are likely to be present at concentrations ≥ 50 ppm. EPA's primary goal is to prevent the export of any regulated levels of PCBs, where PCBs could possibly be mismanaged abroad. If a ship owner knows of documentation that could exclude portions of a material category and the ship owner chooses not to apply that documentation prior to determining random sample locations, then the ship owner could be testing areas that are already known not to contain regulated levels of PCBs.

Chart III.A. EPA Recommended Process for Determining the Presence of Regulated Levels of PCBs on a Vessel to be Reflagged



IV. Non-Sampling Approach

The non-sampling approach detailed in this section makes use of a vessel's historical records. This qualitative weight-of-evidence approach may be used to determine the likelihood that regulated levels of PCBs are not present onboard a vessel. EPA recommends that the ship owner first apply the non-sampling approach prior to applying the sampling approach(es), because the results of the non-sampling approach could alter the number and locations of samples for the sampling approach and may indicate that more comprehensive sampling is unnecessary. The following examples of historical records may be useful in supporting a non-sampling determination:

1) Ship construction information:
    a) Construction shipyard (country)
    b) Years of construction (e.g., keel laying date)
    c) Contemporary PCB laws and regulations banning use of PCBs
    d) Original design drawings, specifications (e.g., equipment), schedules (e.g., paints, lubricants, etc.), deck plans and general arrangement drawings
    e) Manufacturer's product information
    f) Material safety data sheets (MSDSs)

2) Maintenance and repair records:
    a) Location (shipyard and country) and dates of service
    b) Service, maintenance, and modification work carried out (e.g., replacement of fluids, electrical cabling, rubber mounts, equipment or gasketing materials, standards for paint removal and replacement, etc.)
    c) Engineering logs or other records of the vessel's electrical and mechanical systems
    d) Location (shipyard and country) and dates of major equipment replacement
    e) Location (shipyard and country) and dates of dry docking
    f) Materials lists
    g) Manufacturer's product information/specifications
    h) Material Safety Data Sheets
    i) Documentation proving that ordered work was completed

3) Other Information:
    a) Analytical data from previous PCB testing, if available and analyzed per EPA approved extraction methods
    b) Documentation of interviews with vessel crew members
    c) Documentation of questions asked and answered by equipment/product manufacturers

In general, ships constructed in the United States after TSCA was in effect should not contain regulated levels of PCBs at the time of construction. However, EPA recommends that maintenance and repair records for these vessels be evaluated to ensure that subsequent servicing operations (such as repair contracts/shipyard periods) were not conducted in foreign countries where PCBs may still have been in use. EPA considers vessels constructed prior to TSCA coming into effect to be suspect for regulated levels of PCBs. Thus, EPA recommends that if records are to be relied upon as evidence of the absence of regulated levels of PCBs for these vessels, the documentation for any particular category of suspect PCB containing materials should be clear and compelling, that is sufficient to reliably substitute for direct testing for PCBs.

Records of maintenance and repair activities may or may not be available to adequately establish the absence of regulated levels of PCBs. Financiers of commercial vessels typically require that vessels be designed, built and maintained according to certain shipping classification standards. To remain in a particular class, vessels must be periodically surveyed and regular maintenance conducted. The detailed records of these required activities may provide sufficient evidence that one or more categories of suspect PCB-containing materials may be excluded from the PCB sampling plan. In the absence of such documentation, sampling for PCBs is recommended.

Specific examples of documentation useful for establishing the absence of regulated levels of PCBs include, but are not limited to:

- Documentation that a category of suspect materials never contained regulated levels of PCBs (e.g., MSDSs, equipment/product specifications, communications with product manufacturers, etc.); military specifications are typically not useful for such purposes as they are often performance-based and do not contain the specifics of material composition;
- Documentation that applied paint containing or possibly containing regulated levels of PCBs has been removed to National Association of Corrosion Engineers Visual Standard No. 2, or equivalent and repainted with non-PCB paint; or
- Documentation that suspect PCB materials have been removed or decontaminated in the U.S. (post-1979) during a regular maintenance cycle.

If a case can be made strictly from the vessel's records, then the ship owner could choose to conclude that the vessel is very unlikely to contain PCBs at regulated levels using no testing whatsoever. If the records could only be used to conclude that some categories of materials or some items within a category do not contain regulated levels of PCBs, then sampling of the remaining items or categories is recommended from the remaining items or categories.[4]

V. Sampling Approach (both non-targeted and targeted)

If the decision is made to conduct sampling on the vessel, it is recommended that extensive sampling and testing of materials be conducted for every category of material potentially containing regulated levels of PCBs.

Outline of Sampling Process

Appendix II recommends an approach for developing a sampling plan.[5] As a brief overview, ship owners are to consider each category of material that might contain PCBs and decide to:

1) Omit the category from sampling, if:
   a) There are no items in this category onboard the vessel, or
   b) Every item in the category can be sufficiently documented as not containing PCBs at regulated levels.

[4] As noted previously, the ship owner could choose to simply remove the suspect items from the vessel and dispose of them as TSCA regulated materials instead of conducting testing to determine if they contain regulated levels of PCBs.
[5] The sampling plan described in Appendix II is provided as guidance; the ship owner can choose to implement another sampling approach provided it provides the ship owner with the information to determine whether or not the vessel contains categories of materials with regulated levels of PCBs.

2) For those items that are not omitted, include the category in sampling using the following steps:
   a) Determine both the total number of items in that category on the vessel and the number of omitted items due to sufficient documentation showing no regulated levels of PCBs in the item.
   b) Determine the appropriate sample size using the sampling plan tables in Section F of Appendix II.
   c) Construct a sampling frame, listing all of the eligible items in that category that are on the vessel. Eligible items are items that have not been omitted from sampling due to documentation.
   d) Select random samples of the items in the sampling frame. The number of samples is predetermined from step b above.
   e) For each item in the random sample, physically collect or remove enough of the item to perform chemical PCB testing.
   f) If any of the test results indicate PCB concentrations $\geq$ 50 ppm, then that category has tested positive for regulated levels of PCBs. To be able to certify that the ship does not contain materials with regulated levels of PCBs, the ship owner should remediate that category of material (remove or replace the items in that category likely to contain PCBs at regulated levels or test every item in the category and remove those with PCBs at regulated levels); after remediation, consider the category anew, either omitting it from sampling if all items have been removed or replaced, or construct a new sampling frame and sample and test again.

If no items can be omitted from testing, then the sampling plan is said to be *non-targeted,* which would include all categories of materials that may contain PCBs at regulated levels present on the ship. If one or more items of a category or an entire category can be omitted from testing through sufficient documentation, then the sampling plan is said to be *targeted*. Targeted sampling includes only a portion of the entire population of items in the sampling frame.

Schemes for Sampling Approaches

EPA is recommending two different strategies for carrying out either non-targeted or targeted sampling approaches. These strategies are the material category inventory scheme and the zone scheme.

- Material Category Inventory Scheme: This approach calls for the ship owner to take an inventory of all the possible PCB-containing items in a material category (see List II.A) and randomly sample a select number of those items to reach a conclusion probability for a specific conclusion proportion about whether that category contains any items with regulated levels of PCBs.

- Zone Scheme: This approach allows the ship owner to divide the ship into sections prior to conducting the material category inventory approach. This approach could be best applied to non-discrete items, such as paint or caulk. EPA suggests that this approach be applied to sampling paint where the ship owner may have logical sections to be sampled in the vessels based on different paints being removed or applied to different sections of a vessel. For example, the ship owner may have historical records showing that the exterior hull of the ship was stripped and repainted at a separate time than other portions of the vessel, but the ship owner may not know if the paint used on the exterior hull contains regulated levels of PCBs. So in this example, the exterior hull would be one sampling zone for the paint sampling. The benefit of this approach is the ability to remediate the distinct zones if regulated levels of PCBs are found. Dividing the ship or vessel into zones allows for a more efficient sampling, remediation, and resampling cycle, as it allows the sampling planner to target specific zones of the vessel for further remediation and resampling while allowing other zones to be eliminated. EPA does not recommend this scheme for material categories where the items of that category span across zones, such as electrical cabling. If an item spans across multiple zones, then it would be included in the inventory list for each of those zones, which defeats the purpose of the zone scheme.

Appendices I and II contain details of how to apply the Zone Scheme and the Material Category Inventory Scheme, respectively.

Assumptions for the Sampling Approach

This technical guidance document makes two assumptions with regard to the sampling process:

1) Unless otherwise specified in this technical guidance document, shipboard items may be considered to be homogenous with respect to the spatial distribution of PCBs within a given item, thus, the physical sample for testing may be taken from any part of the item that will do the least damage to that item, or a part that is most accessible and safe to sample.
2) This technical guidance document considers PCB testing procedures to have negligibly low error rates with regard to whether the concentration is < 50 ppm or ≥ 50 ppm. If the test indicates that the concentration is < 50 ppm, then the item is considered to have passed the test regardless of the numeric value of the concentration. That is to say that 49 ppm is the same as non-detect; both are < 50 ppm. For the purposes of statistical sampling, similarly 50 ppm is the same as 100 ppm; both are ≥ 50 ppm and either would prompt the ship owner to engage in remediation.

Limitations of the Sampling Approach

There are several limitations with the sampling approaches discussed in this technical guidance document that are important to consider.

First, a conclusion based on a statistical sample provides a known degree of confidence, but not certainty. When using the sampling approach, it is impossible to conclude with 100% certainty that the vessel does not contain PCBs at ≥ 50 ppm without testing every item on the vessel that could contain PCBs. If many randomly selected items are tested and every item tested has concentrations below 50 ppm, then the sampling plan can help the ship owner quantify their confidence that the remaining untested items would also yield test results < 50 ppm.

Second, the degree of uncertainty by the combination of “conclusion probability” and “conclusion proportion” is based on the sampling plan that is developed, especially with regard to a) including every item that could contain PCBs in the sampling frames, and b) selecting the items to test randomly. If any items are excluded from the plan, or if the items tested are not selected in a statistically random fashion, then the degree of uncertainty associated with the “conclusion probability” will likely be different.

Last, there will be practical considerations that make some items impossible to test. Some items that are randomly selected from the sampling frames will be inaccessible or unsafe to sample. This technical guidance will encourage the sampling planner or sampling crew to replace those items with other randomly selected items from the frame. If the inaccessible or unsafe items differ in some way from the other items in the frame in a manner that is related to their PCB concentration, then the degree of uncertainty associated with the "conclusion probability" will likely be different. In particular, if the inaccessible items are more likely to have high concentrations of PCBs than those that are accessible, then the results will be biased when accessible items are tested in the place of inaccessible items.

A. Determining Number of Samples

The sample sizes required to achieve a specified level of confidence about the absence of PCBs at regulated levels will vary from material category to material category depending on several factors. Appendix II describes an approach for identifying the appropriate sample size for each category. If the procedure is followed and test results in all material categories indicate that no PCBs are present at regulated levels, then PCBs are unlikely to be present on the vessel at regulated levels.

Levels of Confidence and Number of Samples

As noted earlier, this technical guidance does not require a ship owner to reach an EPA-specified level of confidence. The ship owner can select the degree of confidence that they desire to achieve, and the level of confidence will correlate with the number of samples needed to reach that level of confidence. This document provides technical guidance on how to achieve a specific level of confidence by selecting a single "conclusion probability" and a single "conclusion proportion." The desired conclusion being: "The probability that this sampling plan would detect PCBs at regulated levels is at least (select a value for probability (e.g., 90%, 95%, or 99%)) if the true underlying proportion of materials containing them were greater than or equal to (select a proportion (e.g., 1%, 5%, or 10%))." The TSCA regulations do not provide for a certain percentage of materials on a vessel to contain regulated levels of PCBs with regard to exports of PCBs for continued use or disposal – when vessel owners choose less stringent statistical parameters for their vessel sampling survey, they proportionally increase their chances of being out of compliance with TSCA requirements.

Higher values of "conclusion probability" and lower values of "conclusion proportion" will provide greater confidence that the vessel does not contain PCBs at regulated levels, although it will also result in larger numbers of items being sampled for PCB testing (i.e., larger sample sizes). Furthermore, because each category of materials can have its own sampling plan and the results from those plans will be combined to draw a conclusion about PCBs on the vessel as a whole, the sample size required in each category of materials will depend on the total number of categories being sampled. When more categories are sampled, higher sample sizes in each category will be needed to achieve the desired level of confidence. This topic is addressed in more detail in Appendix II, Section A: "Statistical Adjustment for Multiple Categories."

Non-discrete Materials

Paint and caulk are two of the material categories from List II.A that can be difficult to itemize into discrete units. Without being able to itemize the material into discrete items, one cannot determine the population number of the category, and therefore cannot setup the sampling frame and the number of samples needed to reach a statistical level of confidence that the material does not contain regulated levels of PCBs. To address this difficulty, EPA recommends that every 400 square feet of painted surface on the ship be treated as one item of paint, because one gallon of paint, which is a typical unit for painting, covers approximately 400 square feet. This does not mean a sample is recommended for every 400 square feet. However, it does mean that the inventory population used to determine the number of samples will be the entire square footage of painted surfaces on the vessel divided by 400. With regard to caulk, if caulk is not found as discrete items on a vessel, then EPA recommends using every 10 linear feet of caulk to be treated as one item of caulk when determining the total number of caulk items in the inventory. See Appendix I for more details on using the zone approach for non-discrete items.

Judgmental Sampling

In addition to random samples collected according to the sampling plan, the sampling crew may use best judgment to collect additional unplanned samples. Examples of extra sampling points include suspicious stains or areas where the sampling crew suspects inadequate cleanup of a spill or inadequate remediation of a previously sampled area containing regulated levels of PCBs. EPA also recommends that sampling crews take additional samples from areas of a ship where they suspect a higher likelihood of PCBs being present, such as boiler rooms, navigation rooms, or control rooms.

Also, heat resistant aluminum (HRA) paint was used in high-heat applications, such as boiler casings, boiler drums and headers and superheated steam lines. HRA paint, as known as "silver" paint, was manufactured with Aroclor 1254 from 1959 until 1967 as per Federal Specification TT-P-28. If the vessel contains silver paint, EPA recommends that the sampling event should include obtaining samples of this paint either under the sampling plan or as judgmental samples.

The sampling crew may also use other historical documentation, such as previous sampling results or ship assessments, to further target areas for additional sampling.

This is similar to EPA's guidance found in Section IV(A)(3) of *Verification of PCB Spill Cleanup by Sampling and Analysis* (http://www.epa.gov/waste/hazard/tsd/pcbs/pubs/sampling.pdf).

Composite Sampling

EPA believes that compositing of samples could be reasonably applied to ships for the sampling approaches recommended in this technical guidance for certain material categories. However, we also believe that only material categories where multiple similar samples can be mixed at equal parts and thoroughly homogenized should be used for composite sampling. The lab should ensure that the composite sample is equally representative of all the individual samples being composited. Paint and caulk are the two material categories that EPA envisions being used in composite sampling. Please note that different material categories should not be composited together into one sample. Also, dissimilar material within the same category should not be composited together into one sample (e.g., cable insulation samples having different physical attributes should not be composited).

Beyond the ability of the material category to be mixed and homogenized, there are three other stipulations for composite sampling.

- EPA recommends that no more than 9 samples (of the same material) should be combined into one composite sample.
- The Quality Assurance/Quality Control Plan associated with composite samples should specify the required practical quantification limit (PQL) that must be achieved for the resulting data from a composite sample to be acceptable for use.

- When evaluating the results, the result for each individual sample added to the composite should be assumed to be the concentration of the composite sample multiplied by the number of individual samples. For example, if 9 individual samples were combined into one composite sample, and the analytical result of the composite sample is 12 ppm, then all 9 individual samples should be assumed to be 108 ppm (9 samples x 12ppm).

When the assumed result for each of the individual samples in the composite is ≥ 50 ppm, then the ship owner has the following options:

1. Remediate/Remove all areas/items where samples were taken,
2. Retest all samples individually to determine which areas/items contain regulated levels of PCBs, then remediate the areas where the samples resulted in regulated levels of PCBs, or
3. Retest portions of the original composite sample into smaller composite samples to narrow down the area(s) in which the PCBs are located without having to retest every individual sample. Then remediate the areas where the smaller composite sample resulted in regulated levels of PCBs.

The EPA recommends that the sampling crew collect and save extra material from each of the individual samples that were combined into the original composite sample, since the subsequent steps could include retesting the individual samples. The compositing should be done by the laboratory rather than the sampling crew.

Because the ship owner may need to collect a relatively large number of samples to maintain a certain level of confidence in the result could be relatively large, EPA believes that this is a practical approach to determine the presence of regulated PCBs and limit the sampling costs incurred by the ship owner without compromising the degree of conclusion probability resulting from the sampling exercise.

Logical Groupings of Items in a Material Category

The ship owner may have historical documentation for specific items or categories of items on their vessel that may not show whether those items do or do not contain regulated levels of PCBs, but the documentation may show that certain items are all related, either in the time of installation on the vessel or the items' manufacturing specifications. In these cases, it could be appropriate to create a subgroup of these items where only one sample or a few samples could be representative of all the items in that subgroup. Additionally, physical attributes, such as color and physical appearance, could be used to create subgroups under a material category. For example, a subgroup under the electrical cable material category could be created based on cables having the same diameter, type of insulation, and color of insulation. However, if the electrical cables have the same diameter, but different insulation either in color or material, we recommend that they not be grouped together, as one cannot make an assumption that cables having different physical attributes would be the same in PCB concentration. Another example is a subgroup of paint based on ship records showing that paint used in several compartments came from one batch of paint. However, when creating subgroups of paint, we recommend that the ship owner ensure that different batches of paint applied during the same maintenance period or painted surfaces that have multiple layers of paint, not be grouped together as they could have different concentrations of PCBs.

If this approach is used, EPA recommends that the items included in the subgroups be removed from the inventory list or population used to create the sampling frame, and each of these subgroups should be sampled.

Sampling in Stages

Under some sampling plans, the number of tests required to successfully implement the plans could be large. If there is good reason to suspect that some test results will yield concentrations ≥ 50 ppm then, we believe it may be advisable to sample a small number of items in an initial phase or screening level assessment. If some of those test results indicate concentrations ≥ 50 ppm, then the ship owner may want to simply begin remediation without the cost and delay of collecting and testing a large number of samples. If all of the test results in the small sample show concentrations < 50 ppm, then additional samples can be collected and tested until the full sample size is reached to achieve the desired level of confidence. This staged approach will be more practical in some situations than others, depending on issues associated with access to the vessel, cost of sampling and tests, and anticipated cost of remediation.

If the approach of sampling in stages or batches is pursued, EPA does not believe it matters which items from the sampling plan are tested first. The first items tested could include the first X number of items randomly selected from the frame, for instance, or they could include X number of items from the list of randomly selected items that are easiest to sample or are all located in one particular portion of the vessel. Provided all of the items from the randomly selected list are eventually sampled and found to have concentrations < 50 ppm, the order in which they are tested and the number that are tested in different batches or stages will not affect the validity or confidence associated with the conclusion.

Quality Assurance / Quality Control (QA/QC) Samples

The number of samples discussed in this section does not include the additional samples needed for the various QA/QC procedures. See Section V.G. for QA/QC information.

B. Determining Sample Locations

In vessels that do contain items with PCBs at ≥ 50 ppm, those items might be: 1) located all around the ship, as in the case of a large batch of fluorescent light ballasts, or 2) concentrated in one small area, as in the case of a contiguous set of compartments that were painted with a small batch of paint containing regulated levels of PCBs. The sampling plans discussed in this technical guidance document are designed to detect regulated levels of PCBs if they appear in a specified percentage (e.g., >1%, >5%, or >10%) of the items in a category on the vessel. The items are selected from random locations all around the vessel.

In order to draw valid conclusions, every item on the vessel that might contain PCBs at regulated levels should have a chance of being included in the random sample of items. Conceptually, no region of the ship should be excluded from testing, unless historical or other information is available which indicates that categories of materials in that region of the ship would not contain regulated levels of PCBs. In a general technical guidance document such as this one, it is difficult to specify regions of vessels that should be tested, so the items to be tested are selected randomly here. However, if the ship owner has reason to believe that a location in the ship is more likely than others to contain regulated levels of PCBs, then it may be prudent to target some testing in that location, above and beyond the random test locations identified by the sampling plans described here (see Section V.A: "Judgmental Sampling" above). Alternatively, the ship owner could establish the materials in those locations as a separate material category, thus creating an additional sampling frame for just the material suspected of containing regulated levels of PCBs (e.g., separating aluminum paint into its own material category).

Sample Collection Sites under the Material Category Inventory Scheme

EPA believes that a material category inventory scheme is well suited for making a statistical determination of the presence of regulated PCBs in discrete items found throughout the entire vessel. We, therefore, recommend that sample sites should be determined randomly from a process like the one detailed in Appendix II.

Designation of Zones

For most categories of materials, this technical guidance document does not give special consideration to the location of the materials, but for purpose of sampling paint and other non-discrete material categories, Appendix I gives an example of applying the zone scheme, which includes identifying zones. When selecting zones by material category, we recommend choosing portions of the ship that roughly contain the same amount of that material.

Appendix I gives technical guidance on calculating a number of painted surfaces used in Appendix II to identify the appropriate number of paint samples. Those samples are collected from the zones in proportions that are calculated using steps in Appendix I.

The reasoning that supports a zone-based approach for paint sampling is that surfaces in shipboard compartments with similar uses will probably have similar painting histories, and so we expect the likelihood of regulated levels of PCBs to be more alike within a zone of compartments of similar use than across zones consisting of compartments with very different purposes. For the other categories of materials considered in this technical guidance document, it is difficult to anticipate which groupings of locations would be more likely to use items from similar manufacturing batches, or similar locations and time periods.

Targeted Sampling

If the ship owner is using historical records to demonstrate that certain items do not contain regulated levels of PCBs, then these items could be removed from the sampling frame. However as shown in Appendix II, these items should still be counted toward the overall material category population which should decrease the number of samples needed from the items in the sampling frame.

Inaccessible Areas

Vessels sampled using this technical guidance could lack electricity, have little or no natural light, have standing water and other liquids, and have blocked or sealed passageways, which may make it difficult to safely reach certain areas of the vessel, such as a submerged hull bottom or submerged interior surfaces (tanks, bilges). Items that cannot be sampled safely should not be sampled. Inaccessible items are items that physically cannot be sampled safely; these items are different from omitted items which are not sampled because they are shown through documentation to not contain regulated levels of PCBs.

When randomly selecting the sample locations on the ship, if a selected location is known to be inaccessible or unsafe, then the sampling planner may randomly select another sample location.

If a ship has areas that are inaccessible or unsafe for sampling that are not known by the sampling planner prior to boarding the vessel to obtain samples, EPA recommends that the planner randomly preselect several alternate sampling locations to be used by the sampling crew when the original sample location is found to be inaccessible or unsafe. If the sampling crew exhausts all of the preselected alternate sampling locations, then EPA recommends the sampling crew use best judgment to determine the remaining sample locations.

The number of inaccessible areas or items will not impact the number of samples recommended in the sampling frame.

Using Readily Available Areas for Sampling

Regardless of the exact location selected for the sample site, sampling crews are free to use their best judgment in determining where the sample will be taken. During the course of collecting samples the sampling crew may find a more readily accessible item near the item designated for sampling. For example, if a cable sample was planned to be taken from a compartment, but the sampling crew entered the compartment and found that the pre-selected cable was running along the overhead and still connected to the junction box, and the crew also found another cable of the same diameter size, insulation type and insulation color (not pre-selected for sampling) already disconnected from that junction box and not live or simply in a more accessible area, then the sampling crew can take the sample for the alternate cable instead of the planned cable. Also, for paint, the sampling crew could choose an area of peeling paint instead of an area pre-selected without peeling paint.

While this could potentially incorporate a small amount of bias in the statistical conclusion of the material and vessel, EPA believes that the practicality of this approach outweighs the potential bias.

Non-Destructive vs. Destructive Sampling

For most categories, EPA does not anticipate sampling to be destructive in nature. However, electrical equipment and electrical cables are two categories where the process of sampling could render the item useless. Therefore, EPA would recommend that the ship owner attempt to find historical records on the presence of regulated levels of PCBs for the majority of electrical equipment on the vessel. This should minimize the amount of potentially destructive sampling performed on electrical equipment (see Section II, "Electrical Equipment"). Regarding electrical cables, EPA recommends that for the purposes of this technical guidance, the concentration of PCBs in a run of cable can be assumed to be consistent throughout the entire cable. From this assumption, a cable can be sampled at the end of a run to minimize destructive sampling of the electrical cables on the vessel (see Section V.C.4, "Cable Insulation Samples").

C. Sample Collection

This section is broken out into the generalized recommended procedures for collecting the different categories of materials in a vessel.

1. Paint Samples

EPA recommends collecting paint samples by hand scraping. Replaceable/disposable blades reduce or eliminate the need to decontaminate sampling equipment. Hand scraping tools are inexpensive and can be easily hand carried through the vessel during a sample event. Electrical powered tools are not recommended because they are cumbersome and the vessels may not have electricity. Chemical strippers or heat are also not recommended to obtain a sample, because chemical strippers or heat could volatilize the PCBs, creating a significant health risk, and making the resulting analytical results unrepresentative and therefore unusable for decision-making purposes.

Consult with the laboratory to determine the amount of sample needed for analysis. A scale will be required if the laboratory specifies a specific weight of sample material. Method 3540C states that a sufficient sample should be introduced into the grinding apparatus (performed by the lab) to yield at least10 grams of sample after grinding (US EPA, Retrieved December 2011, from http://www.epa.gov/waste/hazard/testmethods/sw846/pdfs/3540c.pdf, Procedure 7.1.3.).

Please note that paint sample collection from the hull may have to be done from a support vessel, at a dock, or at a dry dock.

Recommended Materials:

- Nitrile gloves
- Paint scrapers w/ additional blades
- Utility knives and additional razor blades
- Aluminum foil
- Scale, if required by laboratory
- Indelible marker or equivalent
- Reclosable plastic bags, quart size
- Spray paint
- Camera

Sampling Procedure:

1. Don a new pair of nitrile gloves prior to collecting each sample.
2. Select a clean painted surface (approximately 30 cm x 30 cm) from which to take the sample. If the area for sampling is limited and there is dirt on the sample surface then wipe with a clean dry cloth or a clean cloth moistened with water. Do not clean the surface with anything other than water because of the potential for interference or reaction with PCBs in the sample.
3. Remove paint to bare metal using a paint scraper or utility knife.
4. Weigh a piece of aluminum foil.
5. Place the paint sample on the dull side of the pre-weighed sheet of aluminum foil and fold the foil closed.
6. Weigh the sample (subtracting the weight of the sheet of aluminum foil) with a scale to comply with laboratory requirements, if necessary.
7. Put the foil into a reclosable quart size plastic bag.
8. Using an indelible marker, label the plastic bag with the date and time of sample collection, sample identification number, collector's initials, and requested analysis.
9. Follow sample handling and chain-of custody procedures found in Section V.J.
10. Decontaminate all reusable tools that were exposed to paint, according to Decontamination Procedures for Reusable Equipment found in Section V.F.
11. Containerize nitrile gloves, sampling wastes, and disposable tools according to Waste Disposal Procedures in Section V.I.
12. Using spray paint or indelible marker, mark the bulkhead adjacent to the sampling location with the sample date and the sample identification number.
13. Photo document the sample location.
14. Enter sampler's name, sample location, date and time of sample collection, sample identification number and photo number into field notebook.

15. Collect a duplicate sample, if required, as directed in Section V.G: “Field QA/QC.”

2. Wipe Samples

Wipe sample procedures have already been previously documented by EPA. Please see the following: http://www.epa.gov/waste/hazard/tsd/pcbs/pubs/wipe-samp.pdf

Recommended Materials:

- Nitrile gloves
- 100 square centimeter (cm^2) template, disposable
- 3” by 3” sterile gauze, saturated with laboratory grade hexane, in a tightly sealed, 250 mL or 500mL glass amber sample container with Teflon-lined lid
- Indelible marker or equivalent
- Spray paint
- Camera

Sampling Procedure:

1. Don a new pair of nitrile gloves.
2. Place a disposable $100cm^2$ template over the surface to be sampled.
3. Remove the gauze from the sample container and wipe the surface within the template with the gauze. Wipe three times across the template area and three times down the template area.
4. Quickly place the gauze back into the sample container.
5. Place the lid on the sample container and secure tightly.
6. Using an indelible marker, label the sample container with the date and time of sample collection, sample identification number, collector’s initials, and requested analysis.
7. Follow sample handling and chain-of custody procedures found in Section V.J.
8. Containerize nitrile gloves, sample template and any sampling wastes according to Waste Disposal Procedures in Section V.I.
9. Using spray paint or indelible marker, mark the area adjacent to the sampling location with the sample date and the sample identification number.
10. Photo document the sample location.
11. Enter sampler’s name, sample location, date and time of sample collection, sample identification number and photo number into field notebook.
12. A blank wipe sample should be collected at a frequency of one per 20 samples. Additional blank wipe samples (blank spikes & laboratory control samples) should also be collected and supplied to the laboratory as directed in Section V.G: “Field QA/QC.”

3. Liquid Samples

Generally, liquid-filled electrical equipment is not present onboard vessels. However, if a liquid-filled piece of electrical equipment is found, EPA recommends that a liquid sample be obtained at the time the liquid is drained for disposal. EPA strongly recommends against opening a drain valve. First, this equipment may be very old; therefore, once the valve is open the sampler may not be able to close the valve. Second, disturbing the valve may weaken it and create a leak in the future. A liquid sample can be taken if an opening is available on the top of the equipment. EPA recommends using this approach only if there is some urgency to determine the PCB concentration of the liquid.

If samplers collect liquid samples of PCB oils, they need to work closely with the analytical lab. The lab only needs a very small volume (typically less than 30 ml) to analyze a pure product. Samplers should also clearly note on the chain-of-custody form that the sample is oil, and ensure that they are shipping the sample to the lab in accordance with relevant transportation regulations.

Recommended Materials:

- Nitrile gloves
- Coliwasa tube or pipette
- Laboratory supplied 40 ml volatile organic analysis (VOA) vials
- Indelible marker or equivalent
- Spray paint
- Camera

Sampling Procedure:

1. Don a new pair of nitrile gloves.
2. Locate an opening at the top of the equipment.
3. Use a dedicated coliwasa tube or pipette to draw a sample of the liquid and transfer it directly into the laboratory supplied vial. Direct transfer from a Coliwasa device directly to a 40-ml vial is generally a two-person job, and frequently messy. As an alternative step, one can transfer the contents of the Coliwasa device into a disposable container (not plastic, of course), then transfer the sample to a 40-ml vial.
4. Place the lid on the vial and secure tightly.
5. Using an indelible marker, label the sample vial with the date and time of sample collection, sample identification number, collector's initials, and requested analysis.
6. Follow sample handling and chain-of custody procedures found in Section V.J.
7. Containerize nitrile gloves, sampling wastes, and disposable tools or equipment according to Waste Disposal Procedures in Section V.I.
8. Using spray paint or indelible marker, mark the piece of equipment or the wall adjacent to the sampling location with the sample date and the sample identification number.
9. Photo document the sample location.
10. Enter sampler's name, sample location, date and time of sample collection, sample identification number and photo number into field notebook.
11. Collect a duplicate sample, if required, as directed in Section V.G: "Field QA/QC."

4. Cable Insulation Samples

Before collecting samples of cable, EPA recommends that you consult with the laboratory to determine the amount of sample needed for analysis. A scale will be required if the laboratory specifies a specific weight of sample material. The length of cable required for analysis will vary based on the diameter size of the cable. A small diameter cable will require obtaining a longer section of cable as compared to a large diameter cable. Cables should be cut using a bolt cutters or hacksaw. The sampling crew should minimize the amount of heat generated when collecting cable samples, so as to not volatilize the any PCBs that may be in the cable.

If the cables are to remain in service, then it is suggested that a knowledgeable electrician is either present during the sampling event or consulted prior to the sampling event. The electrician can identify points of origin or termination that would be easier to repair for continued use of the cable or could identify other areas along the cable if the points of origin or termination are not accessible. Ensure that no electrical power is running to any cables intended for sampling procedures.

For cable sampling, EPA recommends that a cross section of the cable is cut by the sampling crew and the sample is sent in its entirety to the laboratory for separation and analysis. The laboratory should separate and remove all metal materials from the sample, and all of the remaining non-metal portions of the sample should be homogenized into a single sample and then extracted.

In those limited situations where the cable may contain liquid forms of PCBs, EPA recommends that the liquid be contained so as to avoid the liquid leaking onto other surfaces. Liquids from a cable should be sampled separately from the solid parts of the cable.

Recommended Materials:
- Nitrile gloves
- Bolt cutters and/or hacksaw with additional blades
- Scale, if required by laboratory
- Indelible marker or equivalent
- Reclosable plastic bags, gallon size
- Spray paint
- Camera

Sampling Procedures:
1. Don a new pair of nitrile gloves.
2. Remove an appropriate length of cable from the origin or termination of a cable run using bolt cutters or a hack saw.
3. Use a scale to weigh the cable sample, if the laboratory requested a specific weight of sample.
4. Place the cable sample in a reclosable plastic bag. Do not remove the outer sheath or separate the non-metallic components from the metal components. The laboratory should be instructed to do all separation.
5. Using an indelible marker, label the plastic bag with the date and time of sample collection, sample identification number, collector's initials, and requested analysis.
6. Follow sample handling and chain-of custody procedures found in Section V.J.
7. Decontaminate bolt cutters or other reusable tools that were exposed to the cable, according to Decontamination Procedures for Reusable Equipment found in Section V.F.
8. Containerize nitrile gloves, sampling wastes, and disposable tools according to Waste Disposal Procedures in Section V.I.
9. Using spray paint or indelible marker, mark the bulkhead adjacent to the sampling location with the sample date and the sample identification number and tag the sampled cable line.
10. Photo document the sample location.
11. Enter sampler's name, sample location, date and time of sample collection, sample identification number and photo number into field notebook.
12. Collect a duplicate sample, if required, as directed in Section V.G: "Field QA/QC."

5. Gaskets, Isolation Mounts, Foundation Mounts and Caulk Samples

Gaskets, isolation mounts, foundation mounts, and caulk samples may contain PCBs. Gaskets are found in air handling ducts and around doors and hatches, and between flanges on other shipboard equipment (e.g., valve and pipe flanges). Generally, gasket material is either rubber or felt. Isolation mounts and foundation mounts are installed between a piece of equipment and its attachment point to the vessel. The mount acts as a shock absorber. The mounts are rubber material. Caulk can be found in various places on board a vessel.

Before collecting the samples, EPA recommends you consult with the laboratory to determine the amount of sample of gaskets, isolation mounts, foundation mounts, and/or caulk is needed for analysis. A scale will be required if the laboratory specifies a specific weight of sample material.

Recommended Materials:

- Nitrile gloves
- Utility knives and additional razor blades
- Pliers
- Screwdrivers
- Aluminum foil
- Scale, if required by laboratory
- Indelible marker or equivalent
- Reclosable plastic bags, quart/gallon size
- Spray paint
- Camera

Sampling Procedures:

1. Don a new pair of nitrile gloves.
2. Using a utility knife, pliers or a screwdriver, remove a piece of gasket, isolation mount, foundation mount or caulking. If the material being sampled is part of a piece of equipment that must remain in service (for example, air handling/ventilation system gaskets), collect the sample by scraping the surface to remove only enough material needed for analyses. Make sure that the paint is removed from the surface prior to collecting the gasket sample.
3. Weigh a piece of aluminum foil.
4. Place the sampled material on the dull side of the pre-weighed sheet of aluminum foil and fold the foil closed.
5. Weigh the sample with a scale (subtracting the weight of the aluminum foil) to comply with laboratory requirements, if necessary.
6. Put the foil into a reclosable quart size plastic bag.
7. Using an indelible marker, label the plastic bag with the date and time of sample collection, sample identification number, collector's initials, and requested analysis.
8. Follow sample handling and chain-of custody procedures found in Section V.J.
9. Decontaminate all reusable tools that were exposed to the gasket, isolation mount, foundation mount or caulk, according to Decontamination Procedures for Reusable Equipment found in Section V.F.
10. Containerize nitrile gloves, sampling wastes, and disposable tools according to Waste Disposal Procedures in Section V.I.
11. Using spray paint or indelible marker, mark the bulkhead adjacent to the sampling location with the sample date and the sample identification number.
12. Photo document the sample location.
13. Enter sampler's name, sample location, date and time of sample collection, sample identification number and photo number into field notebook.
14. Collect a duplicate sample, if required, as directed in Section V.G: "Field QA/QC."

6. Insulation Samples

Insulation found on bulkheads, around refrigeration equipment, pipes and in boiler rooms may contain PCBs. The most common insulation materials are fiberglass, cork, foam and felt. Personnel collecting samples should also be aware that insulation materials, especially on pipes and in boiler rooms, may also contain asbestos; thus, they should take the necessary precautions, including respiratory protection, when sampling this type of material. Please see Section V.D, “Health and Safety,” for references to regulations regarding asbestos.

Before collecting samples of insulation, consult with the laboratory to determine the amount of sample needed for analysis. A scale will be required if the laboratory specifies a specific weight of sample material.

Recommended Materials:

- Nitrile gloves
- Utility knives and additional razor blades
- Aluminum foil
- Scale, if required by laboratory
- Indelible marker or equivalent
- Reclosable plastic bags, quart/gallon size
- Spray paint
- Camera

Sampling Procedures:

1. Don a new pair of nitrile gloves.
2. Using a utility knife remove a piece of insulation. If the material contains asbestos, then cover the exposed area to prevent the release of asbestos fibers. Do not remove the outer materials, lath and other non-insulation materials but rather instruct the laboratory to do any separation that is required. The sampling crew may choose to treat all penetrations (samples) as if the material within contained asbestos.
3. Weigh a piece of aluminum foil.
4. Place the insulation sample on the dull side of the pre-weighed sheet of aluminum foil and fold the foil closed.
5. Weigh the sample with a scale (subtracting the weight of the aluminum foil) to comply with laboratory requirements, if necessary.
6. Put the foil into a reclosable quart size plastic bag.
7. Using an indelible marker, label the plastic bag with the date and time of sample collection, sample identification number, collector’s initials, and requested analysis.
8. Follow sample handling and chain-of custody procedures found in Section V.J.
9. Decontaminate all reusable tools that were exposed to the insulation, according to Decontamination Procedures for Reusable Equipment found in Section V.F.
10. Containerize nitrile gloves, sampling wastes, and disposable tools according to Waste Disposal Procedures in Section V.I.
11. Using spray paint or indelible marker, mark the bulkhead adjacent to the sampling location with the sample date and the sample identification number.
12. Photo document the sample location.
13. Enter sampler’s name, sample location, date and time of sample collection, sample identification number and photo number into field notebook.

14. Collect a duplicate sample, if required, as directed in Section V.G: “Field QA/QC.”

7. Other Bulk Material Samples

Before collection samples of other bulk materials, such as floor or ceiling tiles, tapes, plastics, etc., consult with the laboratory to determine the amount of sample needed for analysis. A scale will be required if the laboratory specifies a specific weight of sample material.

Recommended Materials:

- Nitrile gloves
- Utility knives and additional razor blades
- Pliers
- Screwdrivers
- Aluminum foil
- Scale, if required by laboratory
- Indelible marker or equivalent
- Reclosable plastic bags, quart/gallon size
- Spray paint
- Camera

Sampling Procedures:

1. Don a new pair of nitrile gloves.
2. Using a utility knife, pliers, screwdriver or other appropriate tool, remove a piece of the material.
3. Weigh a piece of aluminum foil.
4. Place the sample material on the dull side of the pre-weighed sheet of aluminum foil and fold the foil closed.
5. Weigh the sample with a scale (subtracting the weight of the aluminum foil) to comply with laboratory requirements, if necessary.
6. Put the foil into a reclosable quart size plastic bag.
7. Using an indelible marker, label the plastic bag with the date and time of sample collection, sample identification number, collector’s initials, and requested analysis.
8. Follow sample handling and chain-of custody procedures found in Section V.J.
9. Decontaminate all reusable tools that were exposed to the other bulk material, according to Decontamination Procedures for Reusable Equipment found in Section V.F.
10. Containerize nitrile gloves, sampling wastes, and disposable tools according to Waste Disposal Procedures in Section V.I.
11. Using spray paint or indelible marker, mark the wall adjacent to the sampling location with the sample date and the sample identification number.
12. Photo document the sample location.
13. Enter sampler’s name, sample location, date and time of sample collection, sample identification number and photo number into field notebook.
14. Collect a duplicate sample, if required, as directed in Section V.G: “Field QA/QC.”

D. Health and Safety

Operations must be conducted in compliance with any applicable OSHA regulations or procedures. EPA recommends that a person who develops a sampling plan based on this technical guidance also develop a Site Safety and Health Plan, and ensures that it is read and signed by all personnel involved in each sampling event. The Site Safety and Health Plan may include, at a minimum, a discussion about PCBs, how to prevent PCB exposure while sampling, and the proper use, decontamination and maintenance of personal protective equipment (PPE). The Site Safety and Health Plan should also include a discussion about the potential presence of asbestos in the materials that would be sampled for PCBs. Sampling in a shipboard environment is likely to expose workers to a variety of hazardous substances, including but not limited to asbestos, as well as a wide range of physical hazards. While this technical guidance does not include specific health and safety recommendations, EPA does recommend that all work pursuant to this guidance document be conducted according to a Site Safety and Health Plan.

As noted previously, some ships do not have electricity, are completely dark in internal spaces, have numerous slip/trip/fall hazards and potential confined space concerns. Some sampling locations are categorized as inaccessible due to these personnel safety concerns (See Section V.B. ‘Inaccessible Areas’ above). As health and safety issues are identified (e.g., additional HAZCOM needs, confined spaces, etc.), EPA recommends that ship owners consult with their respective Federal and State OSHA counterparts.

General Health and Safety References

- 29 CFR 1915: Occupational Safety and Health Standards for Shipyard Employment (http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=72c8a801564a6d767e8cac6634f31a61&rgn=div5&view=text&node=29:7.1.1.1.5&idno=29)
- 29 CFR 1915: Specific Asbestos Regulations under Occupational Safety and Health Standards for Shipyard Employment (http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=25094535d31908bc21195753aaf16666&rgn=div5&view=text&node=29:7.1.1.1.5&idno=29#29:7.1.1.1.5.16.6.2)
- 40 CFR 61 Subpart M: National Emission Standard for Asbestos (http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=25094535d31908bc21195753aaf16666&rgn=div5&view=text&node=40:8.0.1.1.1&idno=40#40:8.0.1.1.1.13)

E. Equipment

The following is a list of equipment that may be needed to collect and handle samples. The list below consolidates all of the recommended sample collection equipment from the various sample collection procedures described in Section V.C, as well as includes other possible equipment for collecting and handling samples. This list is not intended to be all inclusive.

Sample Collection Equipment:

- Utility knives w/ disposable blades
- Paint scrapers
- Bolt cutters
- Hack saw w/ additional blades
- 100 cm^2 wipe sample templates (disposable)
- 250 mL or 500 mL pre-cleaned, wide mouth, glass amber sample containers with Teflon®-lined lids
- 40 ml volatile organic analysis (VOA) vials for liquids

- Pliers, screwdrivers, wrench, socket set, hammer, mallet, chisel, five in one window tool (optional)
- Duct or masking tape
- Coliwasa tube or pipette
- Heavy duty aluminum foil
- Gauze pads
- Hexane
- Distilled or deionized water
- Glass sample containers (1 liter), Teflon®-lined lids (for equipment blanks)
- Enclosable plastic bags, quart and gallon size
- Food or postal scale for weighing samples
- Isopropyl alcohol wipes
- Tape measure (100 foot)
- Permanent marker for marking location(s) of sample(s)

Personnel Protective Equipment:
- Flashlights and batteries
- Light sticks
- Headlamps
- Nitrile gloves
- Leather work gloves
- Hard hat
- Safety shoes or steel toe boots
- Insulated coveralls or Kevlar disposable suits depending on the conditions
- First aid kit
- Respiratory protection, such as air purifying respirators (APR) with appropriate cartridges
- Self-contained breathing apparatuses (SCBAs)
- Signaling devices – two way radios, cell phones
- Personal flotation devices (PFDs)
- Safety glasses with side shields or goggles
- RAD badge, as needed (for radiation)
- 4 gas meters/photo ionization detectors (PID)
- Liquid soap
- Paper towels

Documentation:
- Sample identification labels
- Field log book (bound)
- Camera, film/digital media, spare batteries
- Vessel deck plans (if available)
- Indelible marker
- Paint crayons/spray paint
- Calculator

Sample Handling:
- Chain-of-custody forms
- Packing tape
- Shipping labels

- Bills of lading
- Coolers
- Ice or ice packs
- Custody seals
- Reclosable plastic bags

<u>*Waste Collection:*</u>
- Plastic containers for hazardous and non-hazardous wastes
- Labels for waste containers
- Plastic trash bags

F. Decontamination of Reusable Sampling Equipment

In addition to decontaminating sampling equipment after completion of all sampling, the sampling crew will also need to decontaminate their equipment between samples to ensure there is no cross contamination. However, disposable sampling equipment may be used and may be preferred as it reduces or eliminates the need to carry decontamination solvents and reduces and eliminates the generation of potentially liquid hazardous waste(s). Listed here are the possible materials and recommended procedures for decontaminating sampling equipment.

<u>*Possible Materials Needed:*</u>
- Latex or nitrile gloves
- Containers or buckets to hold wash and rinse solution waste, various sizes may be needed depending on the size of the equipment to be decontaminated.
- 3 Spray bottles, one labeled and filled with tap water, one labeled and filled with deionized or distilled water label and one labeled and filled with a mixture of tap water and non-phosphate detergent, prepared as per manufacturer directions
- Extra tap water
- Extra deionized or distilled water
- Extra mixture of tap water and non-phosphate detergent, prepared as per manufacturer directions
- Hexane (laboratory grade)
- Paper towels
- Isopropyl alcohol wipes
- 2 or 3 long-handled brushes for scrubbing
- Gauze pads
- Aluminum foil
- Plastic sheeting for the decontamination area
- Stainless steel rack, optional
- Labeled DOT-certified drums to hold waste decontamination solutions and expendable supplies
- Containers to keep decontaminated equipment clean until the next use
- Sample containers (provided by laboratory for decontaminated equipment blank samples)
- Health and safety personal protective equipment (PPE).

<u>*Recommended Equipment Decontamination Procedures:*</u>
Consider the use of the following procedure in decontaminating reusable sampling equipment:

1. Select a well-ventilated area to conduct the decontamination.
2. Don a new pair of latex or nitrile gloves.

3. Place plastic sheeting down on floor to prepare the decontamination area.
4. Remove any residue on contaminated equipment with a dry-brush, collecting solid materials in a waste container.
5. Saturate a clean gauze pad with hexane and quickly wipe each piece of used equipment thoroughly with the gauze pad.
6. While working over a waste container:
    a. Spray each piece of equipment with the non-phosphate detergent and tap water mixture and wash with a scrub brush.
    b. Wipe each piece of equipment with an isopropyl alcohol swab and rinse with distilled or deionized water.
    c. Rinse each piece of equipment again with distilled or deionized water.
7. Allow equipment to air dry. If practicable, place equipment on a stainless steel rack or grill to dry.
8. Wrap individual pieces of equipment in aluminum foil until needed.
9. All gauze pads and contaminated waste waters/solutions used for cleaning equipment are to be collected in an appropriate container and properly disposed.

Alternatively, the user could apply the following procedure for decontamination of gross material (e.g., paint chips), which would eliminate the need for a liquid waste container and the need to manage potentially PCB-contaminated wastewater:

1. Don a clean pair of latex or nitrile gloves
2. For each piece of contaminated equipment:
    a) Wipe off and collect gross contamination with a paper towel.
    b) Wipe the equipment with a pre-packaged alcohol wipe.
    c) Both the paper towel and alcohol wipe should be collected in a proper waste container.
    d) Allow equipment to air dry.

Even though the alternative decontamination procedure listed above eliminates the need for liquid waste container, the procedure also deviates from the normal procedures, which could potentially introduce some error in the sampling results.

For more information, the regulations for decontamination standards and procedures for sampling equipment can be found in 40 CFR 761.79(c)(2).

Please note that the sampling crew should collect at least one equipment wipe blank per day to ensure that decontamination is effective.

G. Quality Assurance and Quality Control (QA/QC)

This section discusses field and lab quality assurance (QA) and quality control (QC) needs for ships, where primary data is generated and used to determine future action. EPA recommends that all sampling activities be conducted according to the requirements of a project-specific QA/QC project plan. This plan should ensure that data of appropriate quality and quantity are available for their intended decision-making purposes.

For your field QA/QC work, EPA recommends that you consider: (1) the necessary Data Quality Objectives (DQOs) or DQO Process for your site or project; (2) QA and QC processes and policies already available for you and your organization; (3) EPA and other guidance documents that can inform necessary field QA and QC; (4) new QA and QC documents that may be needed and applied to your site, and (5) any additional QA and QC needs discovered after field work is completed.

QA and QC Structures Already in Existence for Your Site

DQOs and DQO Processes for your Site or Project

For field QA/QC activities, it is important to develop appropriate DQOs and follow the appropriate DQO processes to ensure that field work and activities are addressing the necessary data requirements to enable the decisions that need to be made. Some steps that DQOs or DQO Processes address are:

1. *Problem Statement (Problem Formulation):* Summarize the contamination problem that will require new environmental data, and identify the resources available to resolve the problem; develop conceptual site models as needed.
2. *Decision Identification:* Identify the decision that requires new environmental data to address.
3. *Input Identification(s) for the Decision:* Identify the information needed to support the decision and specify which inputs require new environmental measurements
4. *Study Boundary Definition:* Specify the spatial and temporal aspects of the environmental media that the data is to represent to support the decision.
5. *Decision Rule Development:* Develop a logical "if… then…" statement that defines the conditions that would cause the decision maker to choose among alternative actions.
6. *Specification of Limits on Decision Errors:* Specify the decision maker's acceptable limits on decision errors, which are used to establish performance goals for limiting data uncertainty.
7. *Optimization of Design for Obtaining Data:* Identify the most resource-effective sampling and analysis design for generating data that are expected to satisfy the DQOs.

If you have sites or projects that have used DQOs or the processes previously, consider repeating their use as needed here. For new projects, consider developing DQOs or DQO processes that address the aforementioned issues.

Field QA and QC Structures

The owner, operator or their contractor may already have various QA and QC measures in place for the organization to address PCB or other chemical contamination issues. These structures may be found in organizational or site-specific quality management plans (QMPs), generic or specific quality assurance project plans (QAPPs), Sampling and Analysis Plans (SAPs), or Standard Operating Procedures (SOPs). If you have possession of those documents, they may be able to address some portion of QA and QC needs for your field work, either as a template or in their current form. While these documents may not be able to address the entirety of QA and QC issues raised, they may be able to provide the groundwork for any QA/QC documents that need to be created.

Laboratory QA and QC Structures

For certified laboratories, QA and QC plans and structures are generally mandatory as part of their certification(s) and operations. For PCB sampling and analyses that must be completed by a laboratory, laboratory QA and QC information may be requested to determine your project's QA/QC needs. Additionally, your laboratory will likely request field data for its own analyses, sampling result issues, or clarification needs.

EPA-Necessitated QA and QC Structures

EPA provides many guidance documents related to QA and QC activities, which are provided below. It is important to note that, for many EPA Enforcement Orders and Agreements, certain elements of QA and QC actions may be explicitly required in the Agreement or Order and may need site-specific assistance.

Application of QA and QC to Site Work & Developing QA and QC Documents

QA and QC activities and guidance can be applied to many site activities based on your individual needs. However, for purposes of this technical guidance, QA and QC activities should be focused on activities where new---or, primary---data are generated (e.g., sampling to generate PCB or constituent data points, data collected to delineate a site, general data collection or data application to site work).

It is important to note that QA and QC application can vary widely from project to project based on the work to be completed and the QA and QC policies already in place. For example, in cases where facilities have generic or "built-in" QA and QC policies, QA and QC work will likely involve less time and effort than a project where no QA and QC material previously existed. The same applies to projects where a historical data collection process exists, and the process meets QA objectives. Having documentation and expertise that already address QA/QC will significantly reduce new QA/QC needs.

A listing of QA/QC documents typically used for quality assessment is provided on the EPA quality website (http://www.epa.gov/quality/qa_docs.html). It is important to note that these responsibilities may be shared between the owner/operator, contractor and lab, so documentation and recordkeeping should be completed carefully, and maintained by the appropriate responsible party.

QA and QC During and After Sampling

During Field Work

As necessary field work is completed, it is important that the processes and procedures described in the QA and QC documents, and any related documentation, have been implemented and documented appropriately. In addition, it is important that field work meets the QA/QC standards set forth in the documents so that the necessary analyses may be performed appropriately. As issues arise, or processes or procedures need to be changed, maintain records and documents that reflect the resulting changes to field work and quality assessment.

After Field Work

As field work concludes, it is important that field QA/QC reports and supplemental records document necessary field actions which may be needed for use during lab analysis or interpretation. In addition, maintain field records with those on: planning, lab and/or analysis documentation, which may be finalized long after field work concludes.

Common Control Samples

For the laboratory and ship owner to meet their QA/QC criteria, the following QA/QC control samples may be necessary: equipment blanks, liquid trip blanks, trip spike samples, field blanks, and duplicate samples.

Available Materials

EPA provides multiple guidance documents related to QA and QC issues on the following website: http://www.epa.gov/quality/qa_docs.html.

EPA also provides specific guidance related to QA and QC issues on SW846 on the following website: http://www.epa.gov/waste/hazard/testmethods/sw846/pdfs/chap1.pdf.

H. Sampling Documentation and Recordkeeping

Documentation for a site and its sampling events and actions should accurately and comprehensively account for all necessary statutory and regulatory compliance operations. It should also account for any additional events that the owner/operator believes are necessary for the PCB assessment.

Ship sampling and sampling site documentation and records should meet the corresponding Federal, State and local recordkeeping regulations (e.g., RCRA, TSCA). In short, to meet the requirements: *any and all PCB compliance records should be maintained*. Additionally, the ship owner may also choose to keep records that the owner believes are responsive to regulatory requirements (e.g., records showing no PCBs). In light of unexpected future activities where adequate recordkeeping could be beneficial (e.g., future spills or releases, sale of the vessel, rejection of the vessel from the importing country due to the discovery of PCBs), it may be prudent for the ship owner to keep the appropriate records for the vessel, even if at the time of collecting the records, the records are not required by regulation.

General Sampling and Sampling Site Documentation Steps

It is recommended that each member of the sampling crew be assigned a specific task (e.g., taking photos, obtaining samples, generating documentation), which they perform for the entire sampling event. In order to meet the goal of collecting adequate project documentation or recordkeeping, consider implementing the following general steps:

1. Gather and organize any key historical documents, records, or information which could be used for new sampling and sampling site documentation;
2. From those records, for the project to be completed, determine: (a) the appropriate actions that are necessary, and (b) what, if any, documentation or records are required or needed;
3. As sampling and site work proceeds--and is completed, ensure that any actions requiring or needing documentation have appropriate records; and
4. Maintain documentation and records after site or project completion to show actions were fully completed.

For the PCB assessment, the vast majority of EPA-related sampling and sampling site documentation will likely involve work completed for compliance with TSCA and the PCB regulations set forth under 40 CFR Part 761. However, where any applicable requirement necessitating records or documentation exists, recordkeeping and documentation should be maintained. Also, where policy or guidance has a major role in determining a procedure or process, consider maintaining documents or records to indicate that the policy or guidance was followed.

Specific Actions to Consider

For Step 1 (above): Gather and Organize Key Historical Documents, Records and other Information

Before creating new records, EPA recommends that you gather and organize any previous records that may inform site actions, both sampling and remedial. Examples of historical information include:

- Previous quality management plans (QMPs), quality assurance project plans (QAPPs), sampling and analysis plans (SAPs), standard operating procedures (SOPs), or data quality objectives (DQOs) processes or data histories from data collections
- Previous vessel reports, histories, inspections or evaluations, or delineation, screening or sampling event records
- Previous material/item evaluations or waste determinations (type, consistency, etc.)
- Previous vessel inspections or evaluations involving problem formulation
- Audits (either internal or external)
- Government Compliance Inspections or Actions

Historical and archival documentation can be critical in helping to develop vessel project needs and delineate project work. However, in using such documentation, it is important to consider whether the documents meet the needs of the project. For example, if primary data were generated from the documentation, did the documentation meet quality assurance (QA) and address necessary data quality objectives (DQOs)? Did the documentation have a corresponding QAPP or SAP? If QA were not met, were memorandums of understanding or affidavits available (if needed)? Were other pieces of documentation provided in lieu of a formal QA document?

Since the site will likely be the entirety of the ship, sampling, sampling site and work/action documentation will be holistic, but also unique to that ship. Some specific documents to consider in this case may be the ship's historical information, previous ship sampling, remediation or other construction activities, or other such documentation (See Section IV).

While most new documentation and records will revolve around creating new sampling activity or construction or remediation documents, previous events, such as previous remediation activities, known contamination events or other records may dictate specific sampling activities.

For Step 2 (above): Determine Actions and New Record/Documentation Needs
After reviewing historical records and information, determine what new actions---sampling- or remediation-based---are needed and what their various documentation and recordkeeping will be. In addition to documentation and recordkeeping, consider what other documents and records may be needed for your organization. From these needs, compile a list of documents and records that should be maintained.

Some examples of documents or records may include:

- Current versions of the previous documents discussed in the historical section
- Sampling and site delineation plans and documents
- Sampling and site quality documents (e.g., QMPs, QAPPs, SAPs, DQOs processes, SOPs and methods), made prior to sampling
- Sampling and site collection documents (e.g., sampling notebooks, site reports, sample forms/sheets, chains of custody, corrective action narratives, etc.)
- Lab documentation and records (e.g., results, QA/QC reports, etc.)

For Step 3 (above): Ensure Actions Are Documented Appropriately

As actions are completed (e.g., sampling and site work), EPA recommends the records and documentation are developed appropriately and according to your needs. For example, if a sample requires notations in a field notebook, ensure that those notations are completed. Consider periodic check-ins as sampling and site work proceed to ensure that records and documents are maintained.

For Step 4 (above): Maintain Documents and Records
After sampling and site work are completed, EPA recommends that all records and documents be maintained and available as needed, preferably in one permanent location known to all responsible parties. It is important to maintain sampling and site work records, because if the documents and records are lost, no proof of that work exists, which may result in additional sampling or site work.

While this document and activity outline is not intended to be exhaustive, it is meant to provide examples of documentation that could be generated throughout sampling events, whether in planning, implementation, or reporting. In general, as documents are developed in accordance with this technical guidance, EPA recommends that the documents be maintained until transferred to the new owner/operator, or determined to no longer be necessary by Federal, State and local laws and regulations.

Documenting the Sampling Event

When documenting site and sampling activities, EPA recommends the sampling crew first:

- Establish a sample identification numbering system
- Assign each sample a unique identification number.
- Label each container with the sample identification number, date and time of collection, media (e.g., paint, caulk, etc.), requested analysis (PCBs) and collector's initials.

For each sample, EPA also recommends recording the following sample information in the project field notebook:

- Sample identification number
- Date
- Time of collection
- Sample media (e.g., paint, cable, etc.)
- Detailed description of each sampling location including:
    - Functional area and frame number for the compartment or nearest frame mark
    - Deck Number as written on deck plans
    - Compartment number on the door nearest the sampling site location
    - Distance from bow and distance from starboard side of hull (may not be necessary if the sample location can be relocated based on functional area, deck number, and compartment number)
    - Sample location from within the compartment/space (deck, bulkhead, and overhead [plus the distance from the deck for bulkhead samples])
- Detailed description of each sample which could include:
    - Color and texture of paint (for paint media)
    - Number of layers of paint (for paint media)
    - Cable diameter size, insulation type, and insulation color (for cable media)
- Collection of any QA/QC samples
- Record any information, problems or issues encountered during sampling including:

- Deviations from the sampling guidance and difficulties collecting samples
- Reason(s) a sampling location is ineligible

In addition, consider the following documentation methods for your sampling activities:

- Use a bound book (not a loose leaf or spiral bound notebook) for the project field notebook, with each page numbered sequentially and initialed by sampling personnel. The first notation each day should be a site description including weather, vessel name and description, maps and drawings and sampling personnel names. Make all notes in indelible ink so that there will be no erasures.
- Correct any documentation errors by drawing a single line through the error so it remains legible and initial and date the corrected information written adjacent to the error.
- Photographs or video may be used to supplement written records, but should not be used to replace written records.

Appendix *I.E.* shows an example of a sample log sheet.

I. Waste Disposal

The focus of this technical guidance document is on determining the presence of regulated levels of PCBs on a ship. However, EPA recognizes that PCB waste can be generated by sampling or remediation activities, so the following high-level information is being provided on PCB waste disposal.

Requirements and Guidance

For ship PCB waste disposal, it is important to ensure that compliance with TSCA Section 6(e) and 40 CFR Part 761, Subpart D is maintained. To address these requirements, all PCB waste streams should be identified, categorized and managed based on the best available information, and in compliance with the applicable statutory and regulatory requirements.

There are multiple guidance documents to assist owners and operators with PCB waste disposal and assist with compliance, of those having PCB wastes, including: (1) EPA guidance documents, (2) EPA Regional PCB Coordinator guidance and (3) EPA Agreements/Orders. EPA guidance documents relating to PCB disposal and cleanup can be found on EPA's PCB website (http://www.epa.gov/waste/hazard/tsd/pcbs/index.htm).

As the regulations for PCB waste disposal are based on the type of PCB waste and limited to PCBs, it is also important to make note of the waste type, as well as wastes that may not fall under TSCA (e.g., RCRA hazardous waste), and what requirements those wastes may have.

Applying Statutes, Regulations and Guidance

After consulting applicable documents and making necessary determinations for compliance, you should consider developing documentation to record waste handling and disposition actions on site, including categorization (e.g., sampling or generator knowledge), aggregation (e.g., how wastes were bulked together), storage (e.g., when, where, how and how long waste was stored) and disposition (e.g., TSD information, manifests, Certificates of Destruction, etc.).

If your facility does not have its own laboratory, it will most likely use an offsite laboratory for conducting PCB analysis. When transporting samples for PCB analysis, your facility and the laboratory are exempt from meeting the manifesting requirements if they are: (1) being stored and sent by your facility to the laboratory for testing, (2) stored by the laboratory prior to testing, and (3) returned to your facility by the laboratory after testing. Please note that if the sample is determined to contain regulated levels of PCBs, then a manifest will be required for disposal 40 CFR 761.65(i)(2)-(4).

Also, State regulations should be consulted as some States may treat PCB waste as a RCRA hazardous waste.

Storage Requirements

If the ship owner is disposing of PCB waste, then the owner should be aware of the PCB storage regulations for disposal (40 CFR 761.65). For a narrative of the PCB storage requirements, see pages 3-11 through 3-17 of *A Guide for Ship Scrappers – Tips for Regulatory Compliance* (http://www.epa.gov/Compliance/resources/publications/civil/federal/shipscrapguide.pdf). Please note that the url for EPA Form 7710-53 in *A Guide for Ship Scrappers* document on page 3-12 is obsolete. The information for Form 7710-53 can be found on the EPA PCB home page: http://www.epa.gov/waste/hazard/tsd/pcbs/index.htm

J. Sample Handling and Custody

EPA recommends that you consider the following steps for sample handling and custody:

1. Affix a chain-of-custody seal to each sample container or plastic bag after collecting the sample.
2. Fill out and sign a chain-of-custody form for all samples and retain copies thereof. Personnel performing the sampling may use a chain-of-custody form from their organization. Include the following information:
    - Project name
    - Signatures of samplers
    - Sample identification number
    - Date and time of collection
    - Media (paint, cable, etc.)
    - PCB analysis required
    - Signatures of personnel involved in sample transfer
    - Air bill or bill of lading tracking number
3. Pack all samples in coolers. Liquid samples should be packed in a cooler with ice or ice packs. Solid samples do not need to be kept on ice. If samples were collected in manila envelopes, place the envelopes in plastic bags before placing the samples in a cooler. The use of plastic in this instance will not contaminate samples as no direct contact occurs.
4. Package chain-of-custody paperwork in a plastic bag and place in the cooler (taped to the inside of the cooler lid) prior to sealing. The user may also wish to include copies of sample worksheets or notebook pages with sample information, but typically the laboratory would not use these.
5. Secure the cooler shut by fastening tape around the cooler.
6. Affix a chain-of-custody seal to the cooler at two points along the front of the cooler at the point where the lid meets the body of the cooler.
7. Ship or deliver all samples to the laboratory on the day of collection unless a secure storage area has been identified.

Also see related reference material in Section IV.E.2.e of “Verification of PCB Spill Cleanup by Sampling and Analysis” (EPA-560/5-85-026, 1985)
http://www.epa.gov/waste/hazard/tsd/pcbs/pubs/sampling.pdf

K. Analytical Methods

The EPA publication SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods,* specifies hold times for extraction and analysis of organic samples. SW-846 states that samples must be extracted and analyzed within the specified holding times for the results to be considered reflective of total concentrations and that analytical data generated outside of the specified holding times must be considered to be minimum values only.

Sample Extraction:

- Solid Samples:

- The laboratory should adequately prepare solid samples like paint, caulk and gaskets by chopping, grinding, or cutting the sample into small pieces so as to increase the surface area available for extraction. For samples such as paints, caulks and gaskets, laboratories many times require advanced notification of the sample submission for laboratory preparation.

- EPA recommends the use of EPA SW-846 Method 3540C - *Soxhlet Extraction* (http://www.epa.gov/waste/hazard/testmethods/sw846/pdfs/3540c.pdf).

- Method 3540C requires the use of methylene chloride or 10:1 toluene/methanol as the extraction solvent for all materials other than soils/sediments or aqueous sludge samples. In general, EPA recommends that all solid ship material categories samples be extracted using a 10:1 toluene/methanol solution as specified in paragraph 5.4.2.2. of this method. Many of the solid ship material categories contain contaminants that can cause interference during the analysis. Toluene/methanol "cleans" up the sample and eliminates a lot of the interference which the methylene chloride solvent cannot eliminate.

- In general, EPA recommends solid samples for PCB analysis be extracted for analysis within 14 days of sample collection. In addition, EPA recommends that the ship owner should consult with the laboratory to meet the lab’s requirements on the timeline from sample collection to extraction.

- The ship owner should be aware that Method 3540C for solid samples can be problematic for many labs, either because this extraction method is not done regularly, or because the material(s) do/does not work well in the extraction. As a result, labs often have to implement corrective actions or method modifications to improve efficacy. Therefore, before testing, EPA recommends that the owner should discuss these issues with the intended lab to ensure it can perform this PCB extraction on solid samples to meet QA/QC objectives and requirements.

- Liquid Samples (blanks and spikes):

- EPA recommends the use of EPA SW-846 Method 3510(c) – *Separatory Funnel Liquid-Liquid Extraction.*

- In general, EPA recommends aqueous samples for PCB analysis be extracted for analysis within 7 days of collection. In addition, EPA recommends that the ship owner consult with the laboratory to meet the lab's requirements on the timeline from sample collection to extraction.

- Extract Cleanup

PCB extracts often need to undergo a "cleanup" method to remove possible interferences and contaminants. A sample cleanup step may be necessary in order to achieve a quantitation limit of less than 50 ppm. EPA recommends that you refer to EPA SW-846 3600C – *Cleanup* to select the appropriate extract cleanup method.

- Analysis:

- EPA recommends the use of EPA SW-846 Method 8082A - *Polychlorinated Biphenyls (PCBs) By Gas Chromatography* (http://www.epa.gov/waste/hazard/testmethods/sw846/pdfs/8082a.pdf)

- All samples should be analyzed for Aroclors 1016, 1221, 1232, 1242, 1248, 1254, 1260, 1262, 1268 and Total PCBs (PCB_{tot}). Please see Method 8082A for a complete discussion on applying this analysis to PCB congeners.

- In general, EPA recommends both extracts from solid samples and aqueous samples for PCB analysis be analyzed within 40 days of extraction. In addition, EPA recommends that the ship owner consult with the laboratory to meet the lab's requirements on the timeline from sample collection to extraction.

L. Assessment of Sampling Results

The degree of certainty that sampling can provide varies according to the number of samples tested. In general, the more samples analyzed, the greater level of confidence there is that a smaller percentage of the subject material (e.g., paint, caulk) on the vessel may contain ≥50 ppm PCBs. However, even after completing a sampling and analysis study, if any material containing ≥50 ppm PCBs is found on a vessel, the vessel is subject to regulation under TSCA.

Random Sampling of Material by Zones

Assess each of the zones separately. If all samples within a zone are less than 50 ppm PCBs, then the conclusion may be drawn, with the level of confidence (predetermined from the application of the statistical method detailed in Appendices I and II) that no more than the specified percentage of the subject material in the zone is likely to contain PCBs at concentrations of 50 ppm or greater. If all zones individually achieve this result, then the conclusion may be drawn, with the aforementioned level of confidence, that no more than the specified percentage of the subject material on the whole vessel contains PCBs at concentrations of 50 ppm PCB or greater.

In the event that one or more of the samples within a zone is found to contain PCBs at concentrations of 50 ppm or greater, one of the following options may be implemented under this plan:

(1) All of the subject material (e.g., paint) within the zone may be removed/remediated (with appropriate verification that abatement has been effective).

(2) Within the zone, remediate the areas that are known or believed to contain PCBs at concentrations of 50 ppm or greater (or designate them as PCB-containing for future reference), based on the initial sample results, best engineering judgment, historical vessel information and any additional analysis the user may wish to conduct. The areas that are believed not to contain PCBs at regulated levels are subject to re-sampling. For re-sampling, collect and analyze a new full set of samples in that zone in accordance with Appendices I and II. Analyze and evaluate these samples as above.

Repeat the above sequence of sampling, analyzing and clearing of zones as long as needed. As this is a representative sampling plan, resample any zone in its entirety if any sample of the subject material that contains PCBs at concentrations of 50 ppm or greater is found within the zone, in order to achieve the desired level of confidence. This process is discussed in greater detail in Appendix I., Part. F. *Test Results ≥ 50 ppm*.

Random Selection from Material Category Inventory (Acceptance Testing by Attribute)

As with the zone approach, in the material category inventory approach, the degree of certainty that sampling can provide varies according to the number of samples tested; generally, the more samples that are analyzed, the greater the level of confidence that a smaller and smaller percentage of that particular material category as well as all categories tested this way on the vessel may contain ≥50 ppm PCBs.

As detailed in Appendix II, the number of samples required to achieve a desired level of confidence and maximum percentage of materials containing ≥ 50 ppm PCB will be determined based on the number of categories (lots) of material categories (e.g., gaskets, pipe hangers) to be assessed. If no sample in any of the tested material categories show PCBs at ≥ 50 ppm , then the conclusion can be drawn, with the level of confidence specified, that no more than the specified percentage of all the tested material on the whole vessel contains PCBs at concentrations of 50 ppm or greater.

In the event that one or more of the samples within a material category are found to contain PCBs at concentrations of 50 ppm or greater, then that material category, as well as the entire vessel contain PCBs at concentrations of 50 ppm or greater which is regulated under TSCA. In this event, one of the following options may be implemented under this plan:

(1) All of the subject material category (e.g., gaskets) in the vessel may be removed/remediated (with appropriate verification that abatement has been effective).

(2) Continue to test <u>every</u> item from the sampling frame for the category in question and remove those with concentrations ≥ 50 ppm, replacing them, if necessary, with items that are known to have concentrations < 50 ppm. (This option is only available for discrete items.)

(3) Within that particular material category, remediate the portions of that material that are known or believed to contain PCBs at concentrations of 50 ppm or greater (or designate them as PCB-containing for future reference), based on the initial sample results, best engineering judgment, historical vessel information and any additional analysis the user may wish to conduct. The remaining materials of that type that are believed not to contain PCBs at regulated levels and were not remediated are subject to resampling. For resampling, collect and analyze a new full set

of samples in that material category in accordance with Appendix II. Analyze and evaluate these samples as above.

Repeat the above sequence of sampling, analyzing and clearing of groups of material categories, as needed. As this is a representative sampling plan, you must resample any material category in its entirety if any sample of that material category is found to contain PCBs at concentrations of 50 ppm or greater (or remove all material of that type from the vessel).

Appendices I and II contain a detailed discussion of the underlying statistical assumptions made in this sampling plan.

Managing Inaccessible Items when Remediating

Section V.B.: "Inaccessible Areas" (above) includes information on items or areas of a vessel that physically cannot or should not be sampled. While EPA recommends that alternate sample locations be chosen in place of samples from these inaccessible areas or areas that are physically unsafe to sample, EPA does not recommend that these areas or items be ignored during remediation of a category, zone, or the entire vessel. That is, the intent of working around 'inaccessible items' is to practically address inaccessible and unsafe sampling locations; EPA does not intend for 'inaccessible items' to be used as a way to get around sampling portions of the vessel.

As previously stated in this part, if the results of the original sampling plan show items in a category contain regulated levels of PCBs, then the ship owner can choose to remediate an entire category or zone. The ship owner also could choose to remediate/remove only the items sampled that contain PCBs at concentrations of 50 ppm or greater. After remediation/removal, the ship owner can resample that category or zone. Either option should to take into account the "inaccessible areas/items." If the ship owner opts for remediating the entire category or zone, then the ship owner should also remediate the areas/items that were previously marked as "inaccessible." If the ship owner opts for remediating only the items that tested positive for regulated levels of PCBs followed by resampling of the category or zone, then the ship owner should consider how to safely sample from the 'inaccessible items' to get a more accurate assessment of the presence of PCBs on the vessel.

As always, EPA recommends that the health and safety of the sampling crew and remediation crew should be considered first when dealing with these items.

VI. References

PCB References:

International Maritime Organization, 2012, *Guidelines for safe and environmentally sound ship recycling,* International Maritime Organization – Marine Environmental Protection Committee, retrieved December 2012, http://www.imo.org/OurWork/Environment/ShipRecycling/Documents/210(63).pdf

U.S. GPO, *PCB regulations (40 CFR Part 761)*, Retrieved December 2012, from http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=a94d0b6f0c4ebdcc436f39360da0fd23&rgn=div5&view=text&node=40:31.0.1.1.18&idno=40

U.S. EPA, *EPA Light Ballast website*, Retrieved December 2012, from http://www.epa.gov/waste/hazard/tsd/pcbs/pubs/ballasts.htm

U.S. EPA, *EPA PCB website*, Retrieved December 2012, from http://www.epa.gov/waste/hazard/tsd/pcbs/index.htm

U.S. EPA, *EPA Quality System website*, Retrieved December 2012, from http://www.epa.gov/quality/qa_docs.html

U.S. EPA, *EPA Regional PCB Coordinators*, Retrieved December 2012, from http://www.epa.gov/waste/hazard/tsd/pcbs/pubs/coordin.htm

U.S. EPA, *EPA SW-846 Test Method website*, Retrieved December 2012, from http://www.epa.gov/waste/hazard/testmethods/sw846/online/index.htm

U.S. EPA, *TSCA Disposal Requirements for Fluorescent Light Ballasts*, Retrieved December 2012, from http://www.epa.gov/waste/hazard/tsd/pcbs/pubs/ballastchart.pdf

U.S. EPA, 1985, *Verification of PCB Spill Cleanup by Sampling and Analysis*, United States Environmental Protection Agency, Office of Toxic Substances, EPA-560/5-85-026, retrieved December 2012, http://www.epa.gov/waste/hazard/tsd/pcbs/pubs/sampling.pdf

U.S. EPA, 1986, *Field Manual for Grid Sampling of PCB Spill Sites to Verify Cleanup*, United States Environmental Protection Agency, Office of Toxic Substances, EPA-560/5-86-017, retrieved December 2012, http://www.epa.gov/waste/hazard/tsd/pcbs/pubs/gridsampling.pdf

U.S. EPA, 1991, *Wipe Sampling and Double Wash/Rinse Cleanup as Recommended by the Environmental Protection Agency PCB Spill Cleanup Policy*, United States Environmental Protection Agency, retrieved December 2012, http://www.epa.gov/waste/hazard/tsd/pcbs/pubs/wipe-samp.pdf

U.S. EPA, 2000, *A Guide for Ship Scrappers – Tips for Regulatory Compliance*, United States Environmental Protection Agency, Office of Enforcement and Compliance Assurance, EPA 315-B-00-001, retrieved December 2012, http://www.epa.gov/Compliance/resources/publications/civil/federal/shipscrapguide.pdf

U.S. EPA, 2006, *National Guidance: Best Management Practice for Preparing Vessels Intended to Create Artificial Reefs*, United States Environmental Protection Agency and United States Maritime Administration, retrieved December 2012, http://www.epa.gov/owow/oceans/habitat/artificialreefs/documents/0605finalreefguidance.pdf

U.S. EPA, 2009, *PCB Q and A Manual*, United States Environmental Protection Agency, retrieved December 2012, http://www.epa.gov/waste/hazard/tsd/pcbs/pubs/qacombined.pdf

Statistics References:

Grant, Eugene L. & Richard S. Leavenworth, 1980, *Statistical Quality Control*, Fifth Edition, McGraw-Hill, Inc., New York, NY.

Montgomery, Douglas C., 2005, *Introduction to Statistical Quality Control*, Fifth Edition, John Wiley & Sons, Inc.

Squeglia, Nicholas L., 1994, *Zero Acceptance Number Sampling Plans,* American Society for Quality Press, Milwaukee, WI.

Stephens, Kenneth S., 2001, The Handbook of Applied Acceptance Sampling, Plans, Procedures, and Principles, American Society for Quality Press, Milwaukee, WI.

Appendix I: Sampling Approach using Zones

As mentioned throughout this technical guidance document, EPA believes that sampling using the zone scheme is best suited for non-discrete items on a vessel, primarily paint. This appendix is written specifically for the application of paint, but EPA recognizes that the ship owner may find this zone scheme a good fit for other non-discrete material categories.

A. Underlying Statistical Issues with Zone Sampling Approach

Assumptions

Different types of paint are applied to different shipboard surfaces, so it is reasonable to expect PCB levels to vary from location to location in ways that are related to the function of the surfaces, as well as their painting history. Paint may be found in layers that were purchased and applied at a wide variety of times and places. Thus, it may be impossible to determine from records or by visual inspection which surfaces have similar concentrations of PCBs. In general, there are minimal assumptions a ship owner can make about the distribution of PCBs in paint throughout the vessel. PCBs may be concentrated in a few areas or throughout painted surfaces of the vessel.

This technical guidance document recommends categorizing the ship into several *zones* based on compartments having similar purposes and thus likely to have similar types of paint and application history. The decision to include stratification of painted surfaces throughout the vessel into several zones or decision areas is intended to provide a reasonably efficient and effective method for sampling and taking remedial action on the painted surfaces of the vessel based on the sample results. The underlying rationale for delineating different zones or decision areas is based on 'best engineering judgment' (BEJ). The presumption is that persons with experience or BEJ about the likely use of different compartments can categorize the ship's painted surfaces into sampling zones. It should be emphasized that within each zone the sampling areas contain paint that is expected to be more homogeneous in PCB content than painted surfaces in other zones.

Each decision area or zone would be independently evaluated. Paint samples should be obtained from each zone and tested for PCBs. If a sample is found to have PCBs at concentrations ≥ 50 ppm, remediation (removal) of paint in that zone is required prior to export of the ship. It may be argued that a sample with PCBs at ≥ 50 ppm in one zone might reflect on the PCB status of other zones. It is not possible to speculate about that relationship in a manner that applies to all vessels to which this technical guidance might be applied. Assuming that each zone will be evaluated independently allows the ship owner to conduct a straightforward and stepwise sampling and remediation plan for the entire vessel.

Remediation under Zone Scheme

This method allows for a straightforward stepwise protocol for sampling and paint remediation of each zone. If the laboratory analysis shows that any samples from a zone contain PCBs at 50 ppm or above, some type of paint removal/remediation from within that zone is required prior to the export of the vessel. The remediation is followed by another round of sampling. This cycle of sampling and remediation continues for each zone until none of the samples contain PCBs at ≥ 50 ppm.

B. Design of Zones and Number of Samples in each Zone

Design of Zones

In order to implement a sample collection exercise using this technical guidance, a deck plan of the vessel to be sampled should be available, as well as someone who is familiar with the interior use and configuration of the vessel. If there is no one familiar with the interior use and configuration of the vessel, then EPA recommends that someone spend a day or two examining the vessel and marking the deck plan with the appropriate zone designations. Each part of the vessel should be categorized into one of several zones as best determined by the user. An example of zone allocations is described in Section C of this appendix. All painted surfaces in a vessel will fall into one of the several determined sampling zones. In the example shown in Section C below, the first four zones comprise the interior of the vessel and the last two comprise the outer surfaces. A sampling zone may consist of adjacent or non-adjacent areas on a deck; the compartments within a sampling zone on one deck may be contiguous, but they can also be in several non-contiguous locations. A specific sampling zone may consist of component areas from multiple decks, including non-adjacent decks. Each deck may have different sampling zones or combinations of sampling zones. In summary, zones should be designed using the available knowledge of the vessel to aggregate spaces that are likely to contain similar paint.

Proportion of Samples to Collect in Each Zone

The paint samples will be collected from each zone in fractions that approximate the proportion of the vessel's painted surface in that zone to the overall painted surface area of the ship. For example, if a single zone contains 50% of the painted surface of the vessel, then half of the total number of paint samples will be collected from that zone. If the zones contain roughly equal areas of painted surface, then equal numbers of samples should be collected from each zone.

In the absence of specific information about the vessel, this technical guidance document recommends estimating 1/3 of the painted surface area to occur on the exterior of the vessel and 2/3 to occur on the interior. Of the exterior portions of the vessel, about 1/6 of the overall painted surface area can be estimated for the vessel's hull and 1/6 for the weather decks and superstructure. If best engineering judgment indicates otherwise, then the ship owner should make the necessary adjustments and document the basis for these adjustments. In the example used in Section C below, the vessel is split into six zones based on the aforementioned generalities to allow for roughly the same amount of painted surface area between the zones.

Number of Paint Samples to Test for PCBs

The total number of paint items (population) should be the total approximate painted surface area (in square feet) of the vessel divided by 400. Instructions in Appendix II can be used to calculate the number of recommended paint samples in the sampling plan based on the total number of paint items (population).

The number of paint samples to be tested depends on several factors:

1. The approximate total painted surface area on the ship
2. The approximate painted surface omitted from testing due to documentation showing the paint does not contain regulated levels of PCBs
3. The number of logical groupings the user can accurately create. (See Section V.A. Number of Samples.)
4. The degree of certainty with which the user wishes to conclude that the ship is unlikely to contain PCBs at ≥ 50 ppm, as expressed by the conclusion proportion and conclusion probability described in Appendix II

5. The number of categories of materials that will be sampled for PCBs, as described in Appendix II

Note that composite sampling does not alter the number of samples to be taken from the vessel.

C. Example of Six Paint Sampling Zones

This list is not intended to be all inclusive or compulsory, but to give the user suggestions on how to delineate the vessel into the required 6 zones for paint sampling.

1. Living areas:
   - Messes
   - Galleys/Food supply storage
   - Wardrooms
   - Infirmaries
   - Offices
   - Cabins/Staterooms
     - Hall/Corridor spaces/Bulkheads
     - Storage areas
     - Heads (bathrooms)
2. Mechanical/Engineering:
   - Boiler rooms
   - Fire rooms
   - Engine rooms
   - Storage areas
   - Inside the stack
   - Machine shops
     - Hall/Corridor spaces/Bulkheads
3. Operations/Command:
   - Navigation/Chart rooms
   - Bridge
   - Radar/Sonar/Fathometer/Gyroscope
   - Communications/Radio room
   - CIC
   - Hall/Corridor spaces/Bulkhead
4. Specialized Uses:
   - Cargo holds/Ex-ammunition storage areas
   - Steering gear spaces
   - Paint lockers
   - Hangar decks
   - Decompression chambers
     - Hall/Corridor spaces/Bulkheads
5. Weather Decks and Superstructures
   - Deck equipment shelters
   - Anchor windlass and associated equipment
   - Mooring winches
   - Exterior surfaces of the stack
6. Hull:
   - Above the water surface; exposed bottom paint should be included where safe to sample.

D. Detailed Sample Site Selection Procedures

After the ship owner has selected the total number of samples necessary (see details in Section B above and Appendix II), then the ship owner needs to allocate a portion of the total number of samples to each zone. The number of samples for each zone should be proportional to the painted surface area in each zone, where the number of samples allocated to each zone when summed will equal the total number of samples for the vessel.

Consider the following example: Zones 1-6 are found to have approximately 28,000, 28,000, 25,000, 26,000, 31,000, and 30,000 square feet of painted surfaces, respectively. For the purpose of estimating paint sample size, the population of painted surface area will be considered to be the sum of all the surface areas (in square footage) divided by 400, thus 168,000/400 = 420. If no painted surface area can be omitted from the sampling frame due to documentation showing no regulated levels of PCBs, then the sampling frame will also be 420. From the total number used for the population and sampling frame, the ship owner can use the instructions in Appendix II to determine the number of paint samples needed to meet a pre-determined confidence level. If only testing 1 material category (paint), to meet the most stringent levels specified (99% conclusion probability and 1% conclusion proportion), the number of paint samples for the entire ship is 300. After the paint sample size is determined, the samples will be allocated across the zones in the proportions to their individual zone sampling frame painted surface area:

Zone 1: 28,000/168,000 = 16.7%, and 16.7% x 300 = 50 samples
Zone 2: 28,000/168,000 = 16.7%, and 16.7% x 300 = 50 samples
Zone 3: 25,000/168,000 = 14.9%, and 14.9% x 300 = 45 samples
Zone 4: 26,000/168,000 = 15.5%, and 15.5% x 300 = 46 samples
Zone 5: 31,000/168,000 = 18.5%, and 18.5% x 300 = 55 samples
Zone 6: 30,000/168,000 = 17.9%, and 17.9% x 300 = 54 samples

Each zone should contain approximately the same number of samples, because the zones should have been established with approximately the same amount of painted surface area. Omitted painted surfaces should not be included in determining the allocation of the number of samples across the zones. Once the number of samples in each zone is calculated, the user needs to determine the sample sites in each zone.

Methodology for Determining Sample Locations

The methodology described above effectively itemizes the paint into 400 square foot sections for the purposes of determining the overall number of samples in the paint inventory or sampling frame. However, it would be difficult for a ship owner to physically determine the actual 400 square foot sections on the vessel to be included in the sampling frame and subsequent random sample generator. Even if the ship owner could delineate this layout on the ship plans or on the ship itself, EPA recommends that a random site selector method is not appropriate for determining locations for paint samples. Painted surfaces on ships are often applied in batches, where each batch of paint could have a different PCB concentration. Given this assumption, EPA recommends that sampling in evenly spaced increments is more appropriate and will be more effective in finding the different batches of applied paint and thus, more effective in determining whether regulated levels of PCBs are in the paint. Randomly selecting sample locations could result in multiple samples taken from one room and none from several other compartments, thus potentially missing several batches of paint. The intent of this methodology is to test as many unique painted surfaces as possible.

Sample Locations on the Hull (Zone 6)

The appropriate number of samples for the hull is determined through the procedure detailed earlier in this section. In this example, 54 samples are to be taken from the hull. EPA recommends evenly distributing the 54 sample locations across the hull of the vessel both horizontally and vertically. EPA does not intend for the sampling crew to take 54 equidistant samples all on the top edge of the hull. Please note that the EPA believes the painted surface on the hull is a prime candidate for creating a logical grouping that could drastically lower the amount of samples recommended for this area.

Sample Locations on Weather Decks and Non-hull Exterior Painted Surfaces (Zone 5)

There are two general types of painted surfaces in the example Zone 5: weather decks and external surfaces of structures above the main deck of a vessel. The interior surfaces of structures above the main deck, such as captain's quarters, the bridge, and radio/electronics rooms are not included in Zone 5, but will be included in zones 1-4.

In our example, there are 55 samples to be spread across 31,000 square feet of painted surfaces. The user should first estimate the painted surface area for the weather decks (horizontal surfaces) and also for the other external (vertical) surfaces. In the case of this example, approximately 16,000 square feet of painted surfaces are in the weather decks and 15,000 square feet in other external surfaces. The user should split the 55 samples proportionately between them, which would be 28 samples for the weather decks and 27 samples for the other external surfaces.

The 28 samples used for the weather decks can be evenly distributed in a similar manner to the paint sample locations for the hull. If there are dozens of unique weather deck surfaces, EPA recommends again splitting the number of samples proportionately between the unique surfaces. If there are more than 28 unique surfaces, EPA recommends distributing the sample locations to the largest areas first, which unfortunately would leave the smaller surfaces unsampled. However, the sampling planner should use his best judgment when determining sample locations. In some cases the sampling planner may have reason to suspect that a smaller surface will contain regulated levels of PCBs.

The remaining 27 samples for the external surfaces should be distributed in a similar fashion to the samples distributed for the weather decks, which is evenly distributed, but accounting for unique surfaces.

Sample Locations in the Interior Zone (Zones 1-4)

Giving specific technical guidance on how to determine sample locations for the interior zones of a vessel is difficult due to the drastic differences in each type of vessel's layout. Internal compartments for a cargo ship, a ferry, and a military vessel can all be substantially different from one another.

For interior zones, EPA still recommends the high-level approach used for the other zones, which is to evenly distribute the sample locations, but still account for unique surfaces. A few guidelines that EPA can give for interior zone sample locations include:

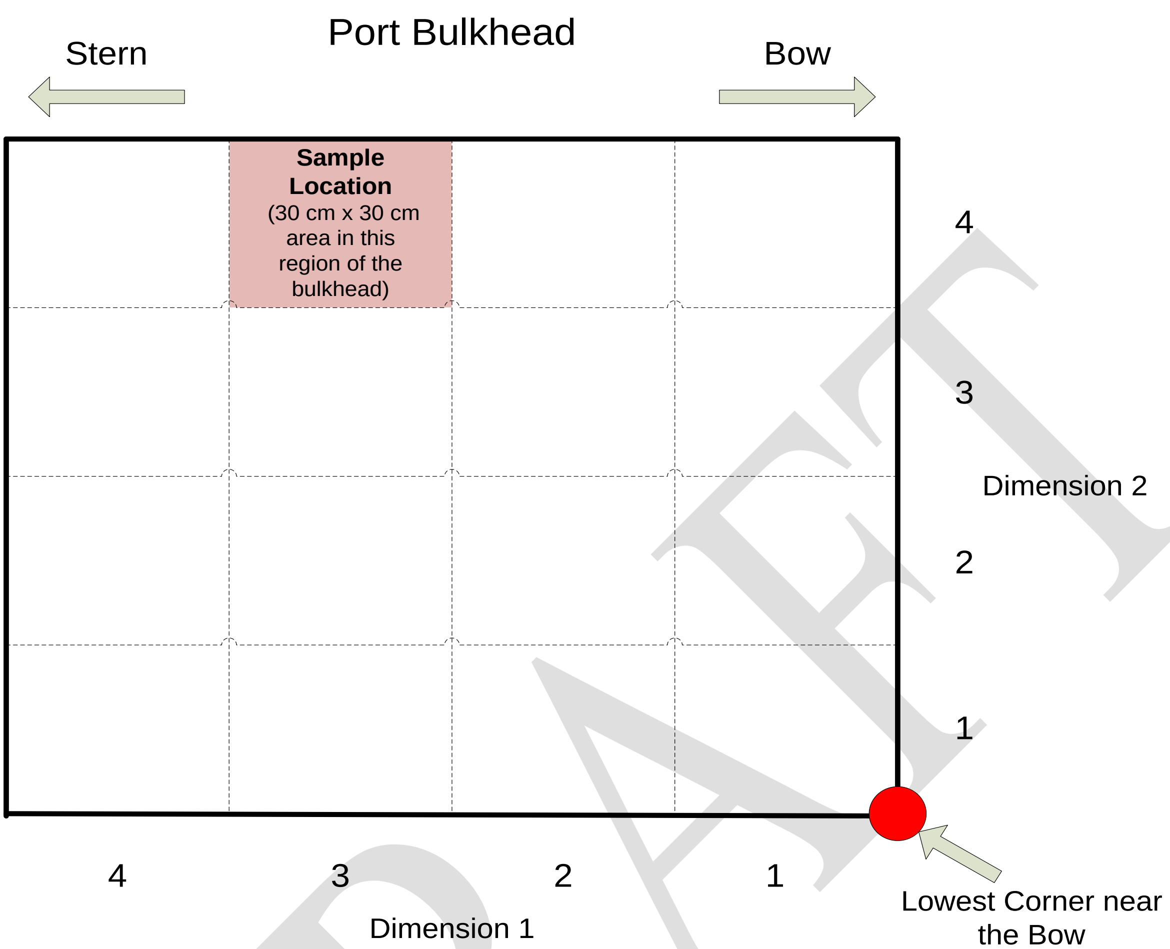
- The painted surface area in each room should be roughly approximated. When evenly distributing the samples throughout the zone, no room should receive a designated second sample location before all the other compartments receive their first designated sample location, unless, the surface area for a compartment is substantially larger than the other rooms in that zone, which may be the case for a zone containing a cargo hold and several smaller compartments.
- Rooms where paint containing PCBs would be more probable, such as boiler rooms, engine rooms, and other mechanical or electrical rooms, should all have at least one sample taken from each room.
- After a room or compartment is selected, the user can randomly select the location of the sample site in that compartment. However, EPA recommends that the user take advantage of the technical guidance for 'Using Readily Available Areas for Sampling' in Section B 'Sample Locations'.

Identifying the Exact Sample Locations for Interior Compartments

EPA recommends that the sampling planner should first randomly determine what surface in the room should be sampled (i.e., overhead, deck, one of the four bulkheads, a pipe, etc.). When it is time to collect the sample, measure the two dimensions of the painted surface to be sampled. Divide each dimension into fourths. Select one corner of the surface to serve as the starting point for measurement. For the sake of consistency, if it is a horizontal surface, select the corner nearest the bow on the port side of the surface. If it is a vertical surface, select the lowest corner near the bow or lowest corner nearest the port side. Divide the painted surface into four fourths in both dimensions and consult the random numbers labeled "random quarter for dimension 1" and "random quarter for dimension 2" to identify which portion of the surface to sample from. If the surface runs fore and aft, then the first dimension is fore and aft. If the surface runs port to starboard, but not fore and aft (i.e., a bulkhead) then the first dimension is port to starboard. However, the sampling planner can use any method they see fit to randomly select the numbers (i.e. 1 through 4) used to determine sample locations.

For example, if the painted surface is a port bulkhead in a compartment, then the reference corner is the bottom corner at the forward end of the room. If the "random quarter for dimension 1" is 3 then the paint sample should be selected in the portion of the bulkhead that extends from ½ to ¾ of its length. If the "random quarter for dimension 2" is 4, then the sample should be selected at a height in the top quarter of that section of bulkhead. Identify a square 30 cm x 30 cm three quarters of the way along the bulkhead and in the top quarter of the bulkhead, and mark it for paint sampling (See Figure I.D. below).

Figure I.D. Example of Identifying Sample Location



If a valid painted 30cm x 30cm sample area cannot be identified or sampled in the portion of the bulkhead identified by the random quarter numbers, then reverse the random numbers and try again. In the above example, make the random quarter for dimension 1 equal to 4 and the random quarter for dimension 2 equal to 3, so go to the fourth quarter back from the forward end of the compartment and go to the third quarter up from the deck. Identify a 30 cm x 30 cm paint sample area in that region of the surface.

If a 30cm x 30cm region does not fit within the randomly selected portion of the surface (i.e., a surface has one dimension that is less than 10cm) then be sure that as much as possible of the sampling area is inside the randomly selected portion. If a sample cannot be obtained from the surface, then select a replacement surface from the sampling frame for that zone and sample it instead.

Ineligible Sample Site Locations

If a sample location, selected based on the ship layout (deck plans), falls within one of the following categories, then EPA recommends that you substitute an alternate (replacement) sample site location:

- The sample location cannot be found (while actually searching the vessel);
- The sample location cannot physically be reached for sampling;

- It would be unsafe for the sampler to collect a sample (provide details in the sampling report);
- It is submerged under water or some other liquid;
- There is no paint or insufficient painted surface at the location (for example a carpeted unpainted deck/floor, an unpainted plastic coated white board on a bulkhead, or a plastic cover over an unpainted reflector and casing of a fluorescent light fixture set into an overhead/ceiling); or
- The sample location is likely to result in cross-contamination from other suspect PCB-containing materials, such as oil spills, or underlying materials such as cable sheathing or gaskets.

The alternate sample site should be as close to the original sample site without violating the basic guidelines established above.

Worksheet to Determine the Allocation of Samples in each Zone

Table I.D.1. Worksheet to calculate the allocation of paint samples to Zones 1-6.

	A	B	C	D	E
Zone	**Approximate square footage of painted surfaces in zone / (400 sq ft)**	**Approximate square footage of omitted painted surface areas in Zone / (400 sq ft)**	**Approximate square footage of non-omitted painted surface areas in Zone / (400 sq ft)**	**<u>Percent:</u> zone non-omitted surface area / total non-omitted surface area**	**<u>Number of Paint Samples:</u> (= Percent x total paint samples determined using Appendix III)**
1	*Determined using deck plans and/or walkthrough*	*Determined using deck plans and/or walkthrough, and historical records*	*= A1 – B1*	*= C1 / C[Total]*	*= D1 x E[Total]*
2			*= A2 – B2*	*= C2 / C[Total]*	*= D2 x E[Total]*
3			*= A3 – B3*	*= C3 / C[Total]*	*= D3 x E[Total]*
4			*= A4 – B4*	*= C4 / C[Total]*	*= D4 x E[Total]*
5			*= A5 – B5*	*= C5 / C[Total]*	*= D5 x E[Total]*
6			*= A6 – B6*	*= C6 / C[Total]*	*= D6 x E[Total]*
Total	*Sum of zones 1-6 (Use this for Column E on Worksheet #2 in Appendix III)*	*Sum of zones 1-6 (Use this for Column H on Worksheet #2 in Appendix III)*	*= A[Total] – B[Total]*	**100%**	*Determined using Appendix III*

E. Example Data Collection Form

Project Number __________ Sample Medium: Paint Date _____________
Vessel Name: ________________ Sampler(s): _______________________ Page ___

Sample Number	Functional Area, Frame number for compartment entry way nearest the sample [in brackets]	Deck Number	Distance from Bow (feet) (or vessel frame number	Distance from Starboard (feet)	Sample Location (random quarters)	Time of Collection	Comments and Observations, e.g. if ineligible, why?
1	Living Quarters [ ]	6			Deck (3,4)		Ineligible (carpeted)
2	Enlisted Mess [ ]	4			Bulkhead (1,2)		Gray paint two obvious layers
3	Storage Area [ ]	1			Deck (4,4)		Gray paint
4	Commissary [ ]	2			Wall (port) (1,2)		White paint three obvious layers
5	Hospital [ ]	3			Wall (stern) (3,1)		White paint thick shiny enamel
6	Living Quarters [ ]	03			Bulkhead (3,2)		Ineligible (sprayed on “popcorn” not painted)
7	Operations Room [ ]	01			Wall (bow) (2,3)		Gray paint
8	Locker room [ ]	5			Deck (3,3)		Ineligible under bolted down locker
9	Briefing room [ ]	02			Bulkhead (1,4)		White paint
10	Recreation room [ ]	7			Wall (bow) (4,3)		Navy blue paint on exterior coating several layers each a different color

F. Subsequent Actions for Test Results ≥ 50 ppm

If one or more samples in a zone contain PCBs at concentrations of 50 ppm or greater, one of the following options may be implemented under this technical guidance:

1. All paint within the zone may be removed/remediated (with appropriate verification that abatement has been effective).
2. Within the zone, remediate the painted areas that are known or believed to contain PCBs at concentrations of 50 ppm or greater (or designate them as PCB-containing for future reference), based on the initial sample results, best engineering judgment, historical vessel information and any additional analysis the user may wish to conduct. The painted areas that are believed not to contain PCBs at regulated levels are subject to re-sampling. For re-sampling, collect and analyze a new full set of paint samples for that zone. Analyze and evaluate those samples as above.

For example, assume that analyses of samples revealed PCB concentrations greater than 50 ppm in 3 samples collected within only one of the original 6 sampling zones. In this case, the other 5 sampling zones do not need to be sampled further, and all additional sampling would be directed at the one zone where regulated levels of PCBs were found. Also assume that the high sample concentrations and past user experience suggested that only paint used for high temperature pipes and fittings was found to contain regulated levels of PCBs. At this point, the user may decide to remove all suspect paint and then resample the remaining paint in the rest of the original zone. In addition, prior to remediation of suspect areas, the user may want to conduct more intensive sampling of the suspect areas in order to more clearly delineate the extent of the regulated levels of PCBs throughout the paint. The goal is to clearly identify and understand which painted areas contain regulated levels of PCBs. The important point is that, under this technical guidance, all areas within the original "hot" zone are subject to re-sampling using a new set of sample locations for that zone. Alternately, the user may wish to simply remove all paint within that one zone and thereby avoid the need for any additional testing.

Repeat the above sequence of sampling, analyzing and clearing of zones as long as needed. This sequence is expected to result in the expeditious clearing of most painted zones and more intensive sampling of painted areas that are found to contain regulated levels of PCBs than those that do not.

As this is a representative sampling guidance, the sampling crew should resample any zone in its entirety if any paint sample, which contains PCBs at concentrations of 50 ppm or greater, is found within that zone, in order to achieve the desired level of confidence. You should not simply remove the sampled paint found to contain regulated concentrations of PCBs, as that paint sample is representative of other unsampled areas of paint, which contain concentrations of 50 ppm or greater, throughout the zone. When re-sampling, generate a complete set of new sample locations in the zone to determine whether all paint containing PCBs at concentrations of 50 ppm or greater has been removed from that zone.

For example, assume that the 30 paint sample locations within a zone, selected in accordance with this technical guidance, showed one sample, within a particular section of deck, as containing regulated PCBs. Based on this result, all paint within that zone would be considered suspect of containing PCBs at the concentrations of 50 ppm or greater. In accordance with this technical guidance, the ship owner should remediate the paint on that section of deck (the 'hot' spot), and then take and analyze 30 new selected samples within the entire zone.

Appendix II: Sampling Approach using Random Selection from Material Category Inventory (Acceptance Testing by Attribute)

A. Overview of Acceptance Testing by Attribute

The statistical framework used here is that of "acceptance sampling." A full review of the field of acceptance sampling is beyond the scope of this document. Concise overviews may be found in Montgomery's *Introduction to Statistical Quality Control* (1980) or Grant & Leavenworth's *Statistical Quality Control* (2005). Acceptance sampling provides a framework for developing a *sampling plan* to help producers and consumers limit the probability that a pre-specified proportion of items in each batch will fail to meet the consumer's specifications.

Briefly, an acceptance *sampling plan* consists of the following quantities and notions. We describe the notions in the manufacturing context first and then apply them to the context of PCBs in ships. Items are considered in batches or *lots*. The *lot size* is the total number of items being considered for acceptance. A subset of the items is *sampled* and *tested*. The number of items sampled is the *sample size*. In the type of plan considered here, the items are tested *by attribute,* which means that test results are considered to be binary: each item falls within the customer's specifications (passes the test) or falls outside them (fails the test). The plan includes an *acceptance number,* which is usually denoted by the lower case letter *c*. If *c* or fewer items from the sample fall outside the specifications, then the lot is judged to fall within the bounds of acceptable quality, and it is *accepted*. If more than *c* items fail to meet the specifications, then the lot is judged to fall outside the bounds of acceptable quality, and it is not accepted. The consequence of a lot not being accepted will vary from context to context. In manufacturing, a failed lot might be sent back to the producer, or it might be subjected to 100% inspection so the consumer can be sure to only use items that meet their specifications.

The *sample size* and *acceptance number* are selected based on the *lot size* and two characterizations of test performance known as the *producer's risk* and the *consumer's risk.* The producer's risk is the probability that a lot with an overall quality level that is acceptable will be rejected because the sample contains an unusually high (not representative) proportion of bad items. The consumer's risk is the probability that a lot with an overall quality level that is unacceptable will be accepted because the sample contains an unusually low (not representative) proportion of bad items. Producer's risk and consumer's risks are expressed as the probability that the lot will be accepted if the true proportion of bad items therein is say *P%* and *C%,* respectively. For example, if the consumer wants 95% of the items in the lot to meet the specifications in order to accept it, the producer may say that the sampling plan should assure that the lot has at least 90% probability of being accepted if the true underlying proportion of items that meet the specifications is 97%, and the consumer may say that the sampling plan should assure that the lot has no more than 10% probability of being accepted if the true underlying proportion of items within specifications is smaller than 92%. Any number of sampling plans (sample sizes & acceptance numbers) may be constructed that meet the criteria specified by the *producer's risk* and the *consumer's risk.* It is usually preferred to select a sampling plan that is likely to result in the minimum amount of total testing to meet the criteria specified by the producer's and consumer's risk.

Acceptance Testing for PCBs in Ships

In the context of PCBs in ships, we consider each category of materials to be a separate lot. The lot size is the number of items on the ship that are made of that material. On any given vessel, each category of materials (lot) will likely have a different lot size or population. For instance, the lot size of rubber gaskets is simply the number of rubber gaskets on the vessel. Similarly, the sampling plan for different materials may employ different sample sizes, as described below, in order to provide uniform levels of confidence about the likelihood of PCBs at regulated levels in the lots. A sampled and tested item will be said to have passed the test if its PCB concentration level is < 50 ppm. It will be said to have failed the test if its PCB concentration level is ≥ 50 ppm.

The acceptance number will be zero for all plans described here. That is to say that if any of the samples yield test results that show PCB levels at ≥ 50 ppm, then the lot will not be accepted and the vessel's owner will need to engage in a remediation process which consists of removing or replacing contaminated materials. After remediation, that category can be re-evaluated with new sampling.

Because it is not permissible to reflag vessels that contain regulated levels of PCBs, the desired proportion of items with PCB concentrations < 50 ppm is 100%. If the sampling plans set $c = 0$, then the notion of producer's risk is not applicable here as it will never be the case that a sampling plan rejects a lot that is of permissible quality. If any of the test results show PCBs at ≥ 50 ppm, then by definition the lot is not of permissible quality and some sort of remediation is required. The notion of consumer's risk is still applicable for any plan that samples and tests a subset of items. This document provides plans to allow the ship owner to specify nine choices of consumer's risk.

In the language of acceptance sampling, one might say that it is of interest to identify sampling plans such that the probability of rejecting the lot (testing at least one item that fails the test) is ≥ 90%, ≥ 95%, or ≥ 99% if the true underlying proportion of items contaminated is ≥ 1%, ≥ 5%, or ≥10%. Conversely, the probability of accepting the lot (all items pass the test) should be < 10%, <5%, or < 1% if the proportion of items contaminated is ≥ 1%, ≥ 5%, or ≥ 10%.

The sampling plan for PCBs in ships will consist of individual plans for each category of material that cannot be omitted from testing based on the vessel's records or some other information. Each category will have its own sample size in the sampling plan based on its lot size and the level of consumer risk identified by the person who develops the sampling plan. The sample sizes will be constructed so that the probability of passing all the tests (having all test results come back < 50 ppm) will be ≥ the probability selected by the user (90%, 95%, or 99%) if the underlying proportion of items with PCB levels ≥ 50 ppm is higher than the proportion selected by the user (1%, 5%, or 10%).

The sampling plan is determined by following the steps in Section D of this Appendix. There are four worksheets involved. Section E of this Appendix includes two examples where the worksheets are filled out.

Statistical Adjustment for Multiple Categories

Because the overall ship sampling plan described here consists of multiple plans – one for each category of materials that cannot be omitted from testing – the sample sizes for each material are adjusted to provide a strong conclusion for the vessel as a whole, and not just for individual categories. When the person constructing the sampling plan selects a probability that the plan will find regulated levels of PCBs if they are present in an underlying proportion, that probability is apportioned across the categories of materials that are sampled. The combined test results yield the desired level of statistical confidence across all sampled categories, not just for each individual category of materials.

For example, if only one category of material were sampled, and the category had 100,000 elements that might contain PCBs on the ship, then a plan that has 95% probability of finding PCBs if they are present in 1% or more of the items would use a sample size of 298 (See Appendix II, Table II-1). But if there were two categories of items to be sampled and each used a sample size of 298, then there would be a 5% probability of mistakenly passing all tests for the first category and a 5% probability of mistakenly passing all tests for the second category, so the overall probability of finding PCBs would be 95% of 95%, or 90.25%. In other words, although the probability of mistakenly passing each category is 5%, the probability of mistakenly passing the entire ship would be 9.75%. In order to preserve a 95% probability of finding PCBs if they are present in any category being sampled, the sampling plans here would recommend sampling 367 items in each of the two categories (See Table II-2).

In statistical language, the sampling plans make a Bonferroni correction for multiple tests, limiting the error in each sampled category to the family-wise probability of Type I error divided by the number of categories of materials for which the testing relies on sampling. Note that there is no uncertainty due to categories that are omitted from sampling. The ship owner may proceed as if they were 100% confident that those categories do not contain PCBs at regulated levels. Note also that there is no uncertainty associated with categories for which census testing is employed. If all of the items in the category are tested, then there is no uncertainty due to sampling. If all of those items pass the test, then the ship owner may be 100% confident that those categories do not contain PCBs at regulated levels. The only uncertainty due to sampling is for the categories that are sampled. Some items are tested and some are not and those that are tested may, by chance, or the luck of the draw pass the test even though there are other items in the sampling frame that would not have passed if they had been selected and tested. Therefore Appendix II.F refers the reader to different sample size tables depending on the number of categories being sampled.

In order to account correctly for sampling uncertainty in multiple categories of materials, the instructions in Appendix II.D have the user identify which categories are omitted from testing, which categories will perform a census (test all items in the category), and which categories will test using a sample. The sample sizes for categories that test only a sample are designed to make a Bonferroni correction for testing across multiple categories and to provide the level of confidence requested by the ship owner when they identify the consumer's risk using a combination of "conclusion probability" and "conclusion proportion" in step 1 of Appendix II.D.

Conduct Census Sampling to Mitigate the Cost of the Bonferroni Correction

In some cases and some categories of material, the number of items that need to be tested will be only slightly lower than the total number of items that are not omitted from testing. It may be financially prudent to perform a census in that category (voluntarily test all of the items that cannot be documented to have PCBs < 50 ppm or presume that all items in that category contain regulated PCBs) and thereby reduce the number of categories being sampled.[6] Reducing the number of categories will decrease the recommended sample sizes in all other categories of materials, which may furnish a net savings in the cost of testing. In other words, it may be worthwhile to test a few more items in one category in order to test many fewer items across the remaining categories. Whether or not this makes financial sense will

[6] As noted previously, the ship owner may also decide to simply remediate this category of materials instead of conducting testing.

depend on the specific costs of sampling and testing, so this document only mentions the possibility and leaves the specific calculation up to the ship owner. The worksheet examples in Section E of this appendix illustrate this point. For the hypothetical vessel named *Ship Y,* the worksheets evaluate whether to sample 6 categories, or to do a voluntary census of one so the number of categories drops to 5 and all the samples sizes (except that in the voluntary census category) also drop. The example yields a net savings in number of tests by choosing to do the census.

B. Equipment for Identifying Items to Test

A sampling frame is a list of every item in a category except for items that are documented to not contain PCBs at regulated levels (omitted item). Some entire categories may be omitted from testing, whereas in other categories, some individual items may be omitted from testing because there is documentation to show that they have concentrations of PCBs below 50 ppm. The sampling frame for a particular category is only the non-omitted items; items that are omitted due to documentation are not included in the sampling frame.

Each sampling frame should be annotated in such a way that the sampling crew can find the item on the vessel if it is selected from the frame for PCB testing. That is to say that the frame should not only list the number of rubber gaskets on a particular deck or in a particular room, but it should unambiguously specify which item in the frame corresponds to which physical gasket in a specific room on a specific deck.

The vessel's records may be helpful in constructing sampling frames for some categories. All of the gaskets, for instance, might already have unique designations in the technical drawings or records of the vessel. If so, those designations and any information needed to locate the item itself, could be copied into the list that forms the sampling frame.

One straightforward way to construct a list and make random selections from it is to use a spreadsheet program. Section C includes instructions for using a spreadsheet to identify a random sample.

C. Sample Selection

In some cases, the number of items in a category of materials will be so small that all of them will need to be tested in order to provide the level of confidence required by the persons who select the "conclusion probability" and "conclusion proportion." In other cases, the number of items will be large enough that a randomly selected sample will afford that same level of confidence. When sampling is appropriate, in order to guarantee the desired level of statistical confidence, it is important that the items be selected randomly from a sampling frame where every item on the vessel that was eligible for testing (i.e., was not omitted from testing by virtue of documentation) had a non-zero probability of being selected for testing in order to convey the level of statistical confidence in the test results.

One straightforward way to manage a sampling frame and make random selections from it is to use a spreadsheet program. Given a list of items, the following instructions may be used to identify a random sample from the list:

1) Put each individual item on the list in a separate row of the spreadsheet, including enough information to unambiguously identify it. Exclude items that have already been omitted from sampling based on documentation showing the item to have PCB concentrations < 50 ppm.

However, the user should create a master list showing both the omitted items and the items included in the sampling frame, which is the population of the category.

2) Insert two new columns in the sampling frame spreadsheet; for the sake of illustration, call them columns A & B.
3) In column A, enter the formula to generate a random number in every row that contains a list item. (In some spreadsheet programs this may be accomplished using the formula =RAND().)
4) Now select column A and press Cntl-C to copy its contents then click Paste->Paste Special (Paste Values) to replace the formula with its results (so the random numbers won't change when the spreadsheet is recalculated).
5) Sort the <u>entire</u> spreadsheet based on column A (Lowest-to-highest or highest-to lowest; it doesn't matter). Be careful not to sort just column A,
6) In column B, enter the number 1 in row 1, the number 2 in row 2, 3 in row 3, and so on until you reach the desired sample size. The rows with 1 up to the sample size in column B are your random sample of items from the sampling frame.
7) Number or label each sample to associate it with the correct sampling frame so that when the PCB concentration results are obtained, it will be possible to identify which items from the frame pass the test (have concentrations < 50 ppm) and which items fail the test with concentrations ≥ 50 ppm.
8) Save the spreadsheet containing the sample frame for future reference.

D. Steps to Develop a Sampling Plan

Sample sizes for all categories of materials may be calculated using a set of four worksheets which appear after these instructions. Several examples where the worksheets are filled in are provided in Section E of this appendix.

<u>Steps for Cover Sheet:</u>

1) Fill in the details about the ship and the persons developing the sampling plan.
2) Select a conclusion probability and a conclusion proportion; write those numbers in the blank spaces provided.

<u>Steps for Worksheet 1:</u>

1) Decide which categories, if any, are omitted from PCB testing for the reasons listed in columns A-D. Put checkmarks in the appropriate boxes. Any row that contains a checkmark should be crossed out in Worksheets 2 & 3. Those rows will not be sampled or tested.
2) Add up the number of rows that do <u>not</u> have checkmarks. The sum is the Number of Categories to Test" or NCT. Write the sum at the bottom of Worksheets 1, 3, and 4.

<u>Steps for Worksheet 2:</u>

1) For categories that are <u>not</u> omitted from PCB sampling, determine how many items (both omitted and non-omitted) in that category are on the vessel; this is the population of the category. Write the total in column E. Note that for paint the total is the approximate total square footage of painted surfaces divided by 400 square feet (see instructions in Appendix I).

2) If any of the items in column E can be omitted from sampling because of documentation, write that number in column F. (square footage can be excluded for paint, but the user needs to convert it to 400 square foot increments)

3) If any items in column E can be omitted by combination of assumption and documentation, write that number in column G. (square footage can be excluded for paint, but the user needs to convert it to 400 square foot increments)

4) Subtract columns F and G from E to determine the size of the population of items in each category that may contain PCBs at regulated levels. The number in column H is the size of the sampling frame and the size of the population from which testing will occur.

<u>Steps for Worksheet 3:</u>

1) Divide H by E and record the ratio to four decimal places in column I. (This is the proportion of items in the category for which results have <u>not</u> already been obtained, via documentation or assumption.)

2) Look up the sample size from the tables in Section F of this appendix where the "Number of Categories" = Number of Categories to Test (NCT). To identify the appropriate sample size in the table you need three numbers:

   a) The "Number of Items on the Vessel" is the number in column E on Worksheet 2.
   b) The "Conclusion Probability" is on the sampling plan cover sheet.
   c) The "Conclusion Proportion" is written on the sampling plan cover sheet.

   Write the sample size in column J. If the sample size is "ALL," then write "ALL" in column J. If the sample size in the table exceeds the number in column E, then write "ALL" in column J and test all of the items.

3) If the table indicates that you should test "ALL" the items in the category, put a checkmark in column L on Worksheet 4.

4) Multiply the number in column J by the number in column I. If the result is a whole number, record it in column K. If the result is not a whole number, round it up to the next whole number and record it in column K. (This is the step that gives credit for results already obtained via documentation or assumption. The only items that remain to be tested are those for which documentation has not been gathered and for which a strong assumption cannot be made based on location and date of manufacture.)

<u>Steps for Worksheet 4:</u>

1) Put a checkmark in column L if K > H or if K is close enough to H that you wish to test all the items in H (perform a census) in order to reduce the sample sizes in other categories.

2) Count the checkmarks in column L. The total is the Number of Categories for Census Testing (NCC). Write this number at the bottom of the worksheet.

3) If there are <u>no</u> checkmarks anywhere in column L, then stop. The sample sizes in column J comprise your sampling plan. Proceed to construct a sampling frame for each category and select a random sample from the frame using the sample size in column J.

4) If there are any checkmarks anywhere in column L, then subtract NCC from NCT. The result is the Number of Categories to Sample (NCS). Write the difference in the appropriate space at the bottom of the worksheet.

5) If NCC > 0 and NCS > 0, then it will be possible to use some smaller sample sizes and still preserve your conclusion probability. Look up new sample sizes for the rows with no checkmarks in column L. Use the table in Section F of this appendix where the "Number of Categories" = Number of Categories to Sample (NCS). The "Total number of items in this category on the vessel" is the number in column E on Worksheet #2. This sample size based on NCS will be multiplied by H/E to give the value of the new sample size, which is to be recorded in column M. These sample sizes will be as small as or smaller than those in column J.

6) The numbers in column M comprise the sampling plan. Proceed to construct a sampling frame for each category that is not omitted from sampling and not subject to a census; select a random sample from the frame using the sample size in column M.

7) Have every item in the random sample chemically tested for PCB concentration (see Section V. K for analytical requirements).

8) If column L indicates that you will do a census of the category, have every item in the category chemically tested for PCB concentration.

9) For paint, use the sample size in column M and follow instructions in Appendix I to apportion the samples across the determined zones.

Sampling Plan Cover Sheet

Vessel Name____
IMO Number____
Owner____
Date & Place of Construction (both date keel laid and completion date)
____
Persons Developing the Sampling Plan ____
____
____

Date the Sampling Plan Was Completed ____

Desired Conclusion: *"The probability that this sampling plan would detect PCBs at regulated levels is at least (select a value for probability: 90%, 95%, or 99%) if the true underlying proportion of materials containing them were greater than or equal to (select a proportion: 1%, 5%, or 10%)."*

Write the Conclusion Probability here: (90%, 95%, or 99%) ________
Write the Conclusion Proportion here: (1%, 5%, or 10%) _________

Please note the user can select a different conclusion probability and conclusion proportion than what is specified on this sheet.

Sampling Plan Worksheet 1 – Identify Categories Omitted from Testing

Vessel Name/IMO Number ________________________

	Omitted from PCB Testing			
	In each row, check one (A-D) if appropriate.			
	There is none of this material on the vessel.	Every item is documented to have PCB concentrations below regulated levels.	Every item can be assumed to have PCB concentrations below regulated levels due to documented year and place of manufacture or installation.	Every item can either be documented or assumed to have PCB concentrations below regulated levels.
	A	B	C	D
Paint				
Electrical cables				
Rubber gaskets				
Felt gaskets				
Insulation material				
Adhesives and tapes				
Caulking/Grouting				
Rubber isolation mounts, foundation mounts, and pipe hangers				
Plastic applications				
Other materials				

Count the number of categories (rows) that do not have a checkmark. That is the Number of Categories to Test (NCT). Write it here and copy it into the appropriate spot on Worksheet 3. ________ (NCT)

Sampling Plan Worksheet 2 –Items That May Contain PCBs at Regulated Levels

Vessel Name/IMO Number ______________________

	Not Omitted from PCB Testing			
	Cross Out Rows That Have A Checkmark on Worksheet #1			
	Population: Total number of items in this category on the vessel. (Determine this number by counting.)	Number that are documented to have PCB concentrations below regulated levels or	Number that can be assumed to have PCB concentrations below regulated levels due to documented year and place of manufacture or installation.	Sampling Frame: Total number of items in this category that cannot be documented or assumed to have PCB concentrations below regulated levels. (H = E - F - G)
	E	F	G	H
Paint				
Electrical cables				
Rubber gaskets				
Felt gaskets				
Insulation material				
Adhesives and tapes				
Caulking/Grouting				
Rubber isolation mounts, foundation mounts, and pipe hangers				
Plastic applications				
Other materials				

Sampling Plan Worksheet 3 – Calculate Sample Sizes to Support Conclusion

Vessel Name/IMO Number ______________________

	Sample Size for PCB Testing Cross Out Rows That Have A Checkmark on Worksheet #1		
	Proportion of items in this category for which results are not currently known (I = H / E)	Sample Size Based on NCT	Preliminary expected number from column H (Work sheet #2) that will need to be tested (K = J x I)
	I	J	K
Paint			
Electrical cables			
Rubber gaskets			
Felt gaskets			
Insulation material			
Adhesives and tapes			
Caulking/Grouting			
Rubber isolation mounts, foundation mounts, and pipe hangers			
Plastic applications			
Other materials			

Copy Number of Categories to Test from Worksheet 1 (NCT) _____

Sampling Plan Worksheet 4 – Revise Sample Sizes Downward Due to Censuses

Vessel Name/IMO Number ______________________

	Sample Size for PCB Testing	
	Cross Out Rows That Have A Checkmark on Worksheet #1	
	Enter a checkmark here if J is “ALL” or if K > H or if K is close enough to H that you wish to test all items in H to reduce the number of categories for sampling (NCS)	Sample size based on NCS
	L	M
Paint		
Electrical cables		
Rubber gaskets		
Felt gaskets		
Insulation material		
Adhesives and tapes		
Caulking/Grouting		
Rubber isolation mounts, foundation mounts, and pipe hangers		
Plastic applications		
Other materials		

Copy Number of Categories to Test from Worksheet 1 (NCT) _____

Count the checkmarks in column L;
the sum is the Number of Categories for Census Testing (NCC) (NCC) _____

Subtract NCC from NCT; this is the Number of Categories to Sample (NCS) (NCS) _____

E. Examples – PCBs on the *Ship X* and the *Ship Y*

This section of the appendix shows examples of filled-in sampling plan work sheets for two hypothetical vessels.

The first example demonstrates the process of filling out the form to obtain sample sizes when no census sampling occurs. This example may represent a large vessel.

The second example demonstrates the process of filling out the form to obtain sample sizes when at least one category must be census sampled. This example might represent a smaller vessel.

Example 1: *Ship X (no census)*

Sampling Plan Cover Sheet

Vessel Name ______Ship X ___________________
Owner _______sample___________________
Date & Place of Construction _______sample___________________
Persons Constructing the Sampling Plan

_______sample________________________________
____
____

Date the Sampling Plan Was Completed______sample_________________________

Desired Conclusion: *"The probability that this sampling plan would detect PCBs at regulated levels is at least (select a value for probability: 90%, 95%, or 99%) if the true underlying proportion of materials containing them were greater than or equal to (select a proportion: 1%, 5%, or 10%)."*

Write the Conclusion Probability here: (90%, 95%, or 99%) ____99%____
Write the Conclusion Proportion here: (1%, 5%, or 10%) ____5%_____

Sampling Plan Worksheet 1 – Identify Categories Omitted from Testing

Vessel Name ____Ship X__________________

	Omitted from PCB Testing			
	In each row, check one (A-D) if appropriate.			
	There is none of this material on the vessel.	Every item is documented to have PCB concentrations below regulated levels.	Every item can be assumed to have PCB concentrations below regulated levels due to documented year and place of manufacture or installation.	Every item can either be documented or assumed to have PCB concentrations below regulated levels.
	A	B	C	D
Paint				
Electrical cables		x		
Rubber gaskets				x
Felt gaskets				
Insulation material				
Adhesives and tapes				
Caulking/Grouting				
Rubber isolation mounts, foundation mounts, and pipe hangers			x	
Plastic applications				
Other materials	x			

Count the number of categories (rows) that do not have a checkmark. That is the Number of Categories to Test (NCT). Write it here and copy it into the appropriate spot on Worksheet 3. ___6_____ (NCT)

Sampling Plan Worksheet 2 –Items That May Contain PCBs at Regulated Levels

Vessel Name ____Ship X____________________

	Not Omitted from PCB Testing			
	Cross Out Rows That Have A Checkmark on Worksheet #1			
	Total number of items in this category on the vessel. (Determine this number by counting.)	Number that are documented to have PCB concentrations below regulated levels or	Number that can be assumed to have PCB concentrations below regulated levels due to documented year and place of manufacture or installation.	Total number of items in this category that cannot be documented or assumed to have PCB concentrations below regulated levels. (H = E - F - G)
	E	F	G	H
Paint	15,050	3,000	500	11,550
~~Electrical cables~~				
~~Rubber gaskets~~				
Felt gaskets	410	0	0	410
Insulation material	500	100	0	400
Adhesives and tapes	400	0	0	400
Caulking/Grouting	230	0	0	230
~~Rubber isolation mounts, foundation mounts, and pipe hangers~~				
Plastic applications	500	0	0	500
~~Other materials~~				

Sampling Plan Worksheet 3 – Calculate Sample Sizes to Support Conclusion

Vessel Name ____Ship X ___________________

	Sample Size for PCB Testing		
	Cross Out Rows That Have A Checkmark on Worksheet #1		
	Proportion of items in this category for which results are not currently known (I = H / E)	Sample Size Based on NCT	Preliminary expected number from column H that will need to be tested (K = J x I)
	I	J	K
Paint	0.7674	125	96
~~Electrical cables~~			
~~Rubber gaskets~~			
Felt gaskets	1	111	111
Insulation material	0.8	111	89
Adhesives and tapes	1	107	107
Caulking/Grouting	1	102	102
~~Rubber isolation mounts, foundation mounts, and pipe hangers~~			
Plastic applications	1	111	111
~~Other materials~~			

Copy Number of Categories to Test from Worksheet 1 (NCT) __6_

Sampling Plan Worksheet 4 – Revise Sample Sizes Downward Due to Censuses

Vessel Name ____Ship X____________________

	Sample Size for PCB Testing	
	Cross Out Rows That Have A Checkmark on Worksheet #1	
	Enter a checkmark here if J is “ALL” or if K > H or if K is close enough to H that you wish to test all items in H to reduce the number of categories for sampling (NCS)	Sample size based on NCS
	L	M
Paint		96
~~Electrical cables~~		
~~Rubber gaskets~~		
Felt gaskets		111
Insulation material		89
Adhesives and tapes		107
Caulking/Grouting		102
~~Rubber isolation mounts, foundation mounts, and pipe hangers~~		
Plastic applications		111
~~Other materials~~		

Copy Number of Categories to Test from Worksheet 1 (NCT) __6__

Count the checkmarks in column L;
the sum is the Number of Categories for Census Testing (NCC) (NCC) __0___

Subtract NCC from NCT; this is the Number of Categories to Sample (NCS) (NCS) __6___

<u>Example 2: *Ship Y (census)*</u>

Sampling Plan Cover Sheet

Vessel Name ______Ship Y__________________

Owner ________Sample_______________________________

Date & Place of Construction ________Sample_______________________________

Persons Constructing the Sampling Plan

________Sample_______________________________

____

____

Date the Sampling Plan Was Completed ______Sample_________________________

Desired Conclusion: *"The probability that this sampling plan would detect PCBs at regulated levels is at least (select a value for probability: 90%, 95%, or 99%) if the true underlying proportion of materials containing them were greater than or equal to (select a proportion: 1%, 5%, or 10%)."*

Write the Conclusion Probability here: (90%, 95%, or 99%) ____95%____

Write the Conclusion Proportion here: (1%, 5%, or 10%) ____1%_____

Sampling Plan Worksheet 1 – Identify Categories Omitted from Testing

Vessel Name ____Ship Y___________________

	Omitted from PCB Testing			
	In each row, check one (A-D) if appropriate.			
	There is none of this material on the vessel.	Every item is documented to have PCB concentrations below regulated levels.	Every item can be assumed to have PCB concentrations below regulated levels due to documented year and place of manufacture or installation.	Every item can either be documented or assumed to have PCB concentrations below regulated levels.
	A	B	C	D
Paint				
Electrical cables				X
Rubber gaskets				
Felt gaskets				
Insulation material				
Adhesives and tapes		X		
Caulking/Grouting				
Rubber isolation mounts, foundation mounts, and pipe hangers				
Plastic applications				
Other materials	X			

Count the number of categories (rows) that do not have a checkmark. That is the Number of Categories to Test (NCT). Write it here and copy it into the appropriate spot on Worksheet 3. ___7____ (NCT)

Sampling Plan Worksheet 2 –Items That May Contain PCBs at Regulated Levels

Vessel Name ____Ship Y____________________

	Not Omitted from PCB Testing Cross Out Rows That Have A Checkmark on Worksheet #1			
	Total number of items in this category on the vessel. (Determine this number by counting.)	Number that are documented to have PCB concentrations below regulated levels or	Number that can be assumed to have PCB concentrations below regulated levels due to documented year and place of manufacture or installation.	Total number of items in this category that cannot be documented or assumed to have PCB concentrations below regulated levels. (H = E - F - G)
	E	F	G	H
Paint	97,500	2,500	1,000	94,000
~~Electrical cables~~				
Rubber gaskets	10,000	500	0	9,500
Felt gaskets	1,500	0	0	1,500
Insulation material	80	0	0	80
~~Adhesives and tapes~~				
Caulking/Grouting	150	75	0	75
Rubber isolation mounts, foundation mounts, and pipe hangers	40	0	0	40
Plastic applications	680	0	50	630
~~Other materials~~				

Sampling Plan Worksheet 3 – Calculate Sample Sizes to Support Conclusion

Vessel Name ____Ship Y________________________

	Sample Size for PCB Testing Cross Out Rows That Have A Checkmark on Worksheet #1		
	Proportion of items in this category for which results are not currently known (I = H / E)	Sample Size Based on NCT	Preliminary expected number from column H (Worksheet #2) that will need to be tested (K = J x I)
	I	J	K
Paint	0.9641	491	473
~~Electrical cables~~			
Rubber gaskets	0.9500	480	456
Felt gaskets	1	436	436
Insulation material	1	ALL	80 (ALL)
~~Adhesives and tapes~~			
Caulking/Grouting	0.500	183 (ALL)	92 (ALL)
Rubber isolation mounts, foundation mounts, and pipe hangers	1	ALL	40 (ALL)
Plastic applications	0.9265	368	341
~~Other materials~~			

Copy Number of Categories to Test from Worksheet 1 (NCT) __7___

Sampling Plan Worksheet 4 – Revise Sample Sizes Downward Due to Censuses

Vessel Name ____Ship Y____________________

	Sample Size for PCB Testing	
	Cross Out Rows That Have A Checkmark on Worksheet #1	
	Enter a checkmark here if J is "ALL" or if K > H or if K is close enough to H that you wish to test all items in H to reduce the number of categories for sampling (NCS)	Sample size based on NCS = 4 vs. those based on NCS = 7
	L	M
Paint		420 (vs. 473 if NCS = 7)
~~Electrical cables~~		
Rubber gaskets		406 (vs. 456)
Felt gaskets		392 (vs. 436)
Insulation material	✓	80
~~Adhesives and tapes~~		
Caulking/Grouting	✓	75
Rubber isolation mounts, foundation mounts, and pipe hangers	✓	40
Plastic applications		311 (vs. 341)
~~Other materials~~		
	Total	1,724 (vs. 1,901)

Copy Number of Categories to Test from Worksheet 1 (NCT) __7___

Count the checkmarks in column L;
the sum is the Number of Categories for Census Testing (NCC) (NCC) __3___

Subtract NCC from NCT; this is the Number of Categories to Sample (NCS) (NCS) __4___

F. Sample Sizes for Sampling Plans

Tables II-1 to II-14 identify sample sizes that will support a strong conclusion of the form: *"The probability that this sampling plan would detect PCBs at regulated levels is at least (select a value for probability: 90%, 95%, or 99%) if the true underlying proportion of materials containing them were greater than or equal to (select a proportion: 1%, 5%, or 10%)."* The tables are to be used with the worksheets described earlier in this appendix. Which tables are used will depend on the number of categories being tested (to identify categories where a census is appropriate) and the number of categories being sampled (as opposed to tested with a census)(to identify sample sizes for the categories being tested).

Within a given table, the sample sizes are higher for larger values of "conclusion probability" and for smaller values of "conclusion proportion". Across tables, the sample sizes in any given cell of the table are larger for the later tables in the appendix – those that make adjustments for more categories. When the table indicates that the sample size is "ALL," a census should be performed for that category; every item in the category should be tested in order to achieve the level of statistical confidence specified in the desired conclusion statement.

Statistical Properties of the Tables

Table II-1 is intended to be used when only one category of materials is being tested. It was constructed using the hypergeometric probability distribution to identify the smallest sample size such that the probability of finding at least one sample with PCBs ≥ 50 ppm in a sample of size "sample size" is ≥ "conclusion probability" if the population of size is "Number of Items on the Vessel" and the true underlying proportion of items with PCBs ≥ 50 ppm is "conclusion proportion".

Conceptually if an urn contains N balls, m of which are blue and N-m of which are pink. Draw n balls from the urn without replacement and call the number of blue balls that are drawn X. X can take any value from 0 up to n. The hypergeometric distribution gives the probability that $X = k$:

$$P(X = k) = \frac{\binom{m}{k}\binom{N-m}{n-k}}{\binom{N}{n}}$$

In this context N is the population of items in a category of materials. The pink balls are items with PCBs at concentrations < 50 ppm and the blue balls are items with PCBs at ≥ 50 ppm. Testing is performed on n items. In the population, the underlying proportion of items with PCBs ≥ 50 ppm is m/N. The probability of obtaining one or more test results at ≥ 50 ppm is 1 minus the probability of obtaining exactly zero test results at ≥ 50 ppm.

Define α to be the probability of obtaining zero test results that are ≥ 50 ppm when the underlying proportion is ≥ "conclusion proportion"; in the language of hypothesis testing, α may be considered the probability of making a Type I error. Then α = 1 – "conclusion probability" which is to say that α = 1%, 5%, or 10%. The sample sizes in table A3-1 are the smallest samples that may be drawn from a population the size of "Number of Items on the Vessel" and have the probability of obtaining exactly zero test results ≥ 50 ppm be ≤ α if the true underlying proportion of items with PCBs ≥ 50 ppm is "conclusion proportion".

For example, the hypergeometric distribution indicates that there is a 4.98% probability of finding zero samples with PCBs ≥ 50 ppm in a random sample of size 298 taken without replacement from a population of 100,000 if the underlying proportion of items in that population with PCBs ≥ 50 ppm is 1%. So the probability of finding at least one sample with ≥ 50 ppm is 100 – 4.98 = 95.02%. Any smaller sample would provide less than 95% probability of finding at least one item with PCBs ≥ 50 ppm.

The remaining tables below incorporate a Bonferroni correction for multiple tests. They assume that the "conclusion probability" applied to "number of categories" tests, so they divide α by the number of categories. Specifically, they use the hypergeometric probability distribution to identify the smallest sample size such that the probability of finding zero samples with PCBs ≥ 50 ppm in a sample of size "sample size" is ≤ (α / "number of categories") if the population of size is "Number of Items on the Vessel" and the true underlying proportion of items with PCBs ≥ 50 ppm is "conclusion proportion". When more than one category is being tested, α is the so-called *family-wise probability of Type I error*, or the probability of making a Type I error in any of the categories being sampled. Dividing α by the number of categories that are being sampled provides the Bonferroni correction for multiple tests. By following the instructions in Appendix II.D., we can be confident that probability of finding at least one item with PCBs ≥ 50 ppm across all the categories being sampled is at least equal to "conclusion probability".

Table II-1. Appropriate Sample Sizes when Number of Categories = 1

Number of Categories: 1										
	Conclusion Proportion	1%			5%			10%		
	Conclusion Probability	99%	95%	90%	99%	95%	90%	99%	95%	90%
Number of Items in 1 Material Category	1-30	ALL	29	28	27	23	21	23	19	16
	31-50	ALL	48	46	39	31	27	29	22	18
	51-75	ALL	72	68	51	39	33	32	23	18
	76-100	99	95	91	59	45	37	36	25	20
	101-200	180	155	137	73	51	41	40	27	21
	201-300	235	189	161	78	54	42	41	28	22
	301-400	273	211	175	81	55	43	42	28	22
	401-500	300	225	184	83	56	43	42	28	22
	501-600	321	235	191	84	56	44	43	28	22
	601-800	349	249	200	85	57	44	43	28	22
	801-1,000	368	258	205	86	57	44	43	29	22
	1,001-2,000	410	277	217	88	58	45	44	29	22
	2,001-3,000	425	284	221	89	58	45	44	29	22
	3,001-4,000	433	288	223	89	58	45	44	29	22
	4,001-5,000	438	290	224	89	59	45	44	29	22
	5,001-7,000	444	292	226	90	59	45	44	29	22
	7,001-10,000	448	294	227	90	59	45	44	29	22
	10,001-20,000	453	296	228	90	59	45	44	29	22
	20,001-50,000	457	298	229	90	59	45	44	29	22
	50,001-100,000	458	298	229	90	59	45	44	29	22
	> 100,000	459	298	229	90	59	45	44	29	22

If the sample size in the table exceeds the number of items on the vessel, then test ALL of the items.

Table II-2. Appropriate Sample Sizes when Number of Categories = 2

Number of Categories: 2										
	Conclusion Proportion	1%			5%			10%		
	Conclusion Probability	99%	95%	90%	99%	95%	90%	99%	95%	90%
Number of Items in 1 Material Category	1-30	ALL	ALL	29	28	25	23	24	21	19
	31-50	ALL	49	48	41	35	31	32	26	22
	51-75	ALL	74	72	54	45	39	35	27	23
	76-100	ALL	98	96	65	52	45	40	30	25
	101-200	186	168	155	81	61	51	45	33	27
	201-300	248	212	189	88	64	54	47	34	28
	301-400	293	241	211	91	66	55	48	34	28
	401-500	326	260	225	94	67	56	48	34	28
	501-600	351	275	235	95	68	56	49	34	28
	601-800	386	295	249	97	69	57	49	35	28
	801-1,000	410	308	258	99	70	57	50	35	29
	1,001-2,000	464	336	277	101	71	58	50	35	29
	2,001-3,000	484	346	284	102	72	58	50	35	29
	3,001-4,000	494	351	288	102	72	58	50	35	29
	4,001-5,000	501	354	290	103	72	59	51	35	29
	5,001-7,000	508	358	292	103	72	59	51	35	29
	7,001-10,000	514	361	294	103	72	59	51	35	29
	10,001-20,000	521	364	296	104	72	59	51	35	29
	20,001-50,000	525	366	298	104	72	59	51	35	29
	50,001-100,000	526	367	298	104	72	59	51	36	29
	>100,000	528	367	298	104	72	59	51	36	29

If the sample size in the table exceeds the number of items on the vessel, then test ALL of the items.

Table II-3. Appropriate Sample Sizes when Number of Categories = 3

Number of Categories: 3										
	Conclusion Proportion	1%			5%			10%		
	Conclusion Probability	99%	95%	90%	99%	95%	90%	99%	95%	90%
Number of Items in 1 Material Category	1-30	ALL	ALL	ALL	28	26	25	25	22	20
	31-50	ALL	ALL	49	42	37	34	33	27	24
	51-75	ALL	74	73	56	48	43	37	29	25
	76-100	ALL	99	97	67	55	49	42	33	28
	101-200	188	174	164	85	66	57	48	36	30
	201-300	255	223	203	93	70	60	50	37	31
	301-400	303	256	229	97	73	62	51	37	31
	401-500	339	279	246	100	74	63	52	38	32
	501-600	367	296	259	102	75	63	52	38	32
	601-800	407	320	276	104	76	64	53	38	32
	801-1,000	433	335	288	106	77	65	53	39	32
	1,001-2,000	494	369	312	109	79	66	54	39	33
	2,001-3,000	517	381	320	110	79	66	54	39	33
	3,001-4,000	529	388	325	110	80	66	54	39	33
	4,001-5,000	537	392	328	110	80	66	54	39	33
	5,001-7,000	546	396	331	111	80	66	54	39	33
	7,001-10,000	552	400	333	111	80	67	54	39	33
	10,001-20,000	560	404	336	111	80	67	55	39	33
	20,001-50,000	565	406	338	112	80	67	55	39	33
	50,001-100,000	566	407	338	112	80	67	55	39	33
	>100,000	568	407	338	112	80	67	55	39	33

If the sample size in the table exceeds the number of items on the vessel, then test ALL of the items.

Table II-4. Appropriate Sample Sizes when Number of Categories = 4

Number of Categories: 4										
	Conclusion Proportion	1%			5%			10%		
	Conclusion Probability	99%	95%	90%	99%	95%	90%	99%	95%	90%
Number of Items in 1 Material Category	1-30	ALL	ALL	ALL	28	27	25	25	23	21
	31-50	ALL	ALL	49	43	38	35	34	28	26
	51-75	ALL	ALL	74	58	49	45	38	31	27
	76-100	ALL	99	98	69	58	52	43	34	30
	101-200	190	178	168	89	70	61	50	38	33
	201-300	259	230	212	97	75	64	52	39	34
	301-400	310	266	241	102	77	66	53	40	34
	401-500	348	291	260	104	79	67	54	40	34
	501-600	378	310	275	106	80	68	55	41	34
	601-800	420	336	295	109	81	69	55	41	35
	801-1,000	449	354	308	111	82	70	56	41	35
	1,001-2,000	516	392	336	114	84	71	57	42	35
	2,001-3,000	541	406	346	115	85	72	57	42	35
	3,001-4,000	554	414	351	116	85	72	57	42	35
	4,001-5,000	562	418	354	116	85	72	57	42	35
	5,001-7,000	572	423	358	116	85	72	57	42	35
	7,001-10,000	579	427	361	117	86	72	57	42	35
	10,001-20,000	588	432	364	117	86	72	57	42	35
	20,001-50,000	593	435	366	117	86	72	57	42	35
	50,001-100,000	595	436	367	117	86	72	57	42	36
	>100,000	597	436	367	117	86	72	57	42	36

If the sample size in the table exceeds the number of items on the vessel, then test ALL of the items.

Table II-5. Appropriate Sample Sizes when Number of Categories = 5

Number of Categories: 5										
	Conclusion Proportion	1%			5%			10%		
	Conclusion Probability	99%	95%	90%	99%	95%	90%	99%	95%	90%
Number of Items in 1 Material Category	1-30	ALL	ALL	ALL	ALL	27	26	26	23	22
	31-50	ALL	ALL	ALL	43	39	36	35	29	27
	51-75	ALL	ALL	74	58	51	46	39	32	28
	76-100	ALL	99	99	70	59	54	45	36	31
	101-200	191	180	172	91	73	64	51	40	34
	201-300	262	235	218	100	78	68	54	41	35
	301-400	315	273	249	105	81	70	55	42	36
	401-500	355	300	271	108	83	71	56	42	36
	501-600	386	321	287	110	84	72	57	43	36
	601-800	431	349	309	113	85	73	57	43	37
	801-1,000	461	368	323	114	86	74	58	43	37
	1,001-2,000	532	410	354	118	88	75	59	44	37
	2,001-3,000	559	425	365	119	89	76	59	44	37
	3,001-4,000	573	433	371	120	89	76	59	44	37
	4,001-5,000	582	438	375	120	89	76	59	44	37
	5,001-7,000	592	444	379	121	90	76	59	44	38
	7,001-10,000	600	448	382	121	90	76	59	44	38
	10,001-20,000	609	453	386	121	90	77	59	44	38
	20,001-50,000	615	457	388	122	90	77	59	44	38
	50,001-100,000	617	458	389	122	90	77	59	44	38
	>100,000	619	458	389	122	90	77	59	44	38

If the sample size in the table exceeds the number of items on the vessel, then test ALL of the items.

Table II-6. Appropriate Sample Sizes when Number of Categories = 6

Number of Categories: 6										
	Conclusion Proportion	1%			5%			10%		
	Conclusion Probability	99%	95%	90%	99%	95%	90%	99%	95%	90%
Number of Items in 1 Material Category	1-30	ALL	ALL	ALL	ALL	27	26	26	24	22
	31-50	ALL	ALL	ALL	44	40	37	35	30	27
	51-75	ALL	ALL	74	59	52	48	40	33	29
	76-100	ALL	ALL	99	71	61	55	46	37	33
	101-200	192	182	174	93	75	66	53	41	36
	201-300	264	239	223	102	81	70	55	43	37
	301-400	318	279	256	107	84	73	57	43	37
	401-500	360	307	279	111	86	74	58	44	38
	501-600	392	329	296	113	87	75	58	44	38
	601-800	439	359	320	116	89	76	59	45	38
	801-1,000	471	379	335	118	90	77	59	45	39
	1,001-2,000	545	424	369	121	92	79	60	45	39
	2,001-3,000	574	441	381	123	92	79	61	46	39
	3,001-4,000	589	450	388	123	93	80	61	46	39
	4,001-5,000	598	455	392	124	93	80	61	46	39
	5,001-7,000	609	461	396	124	93	80	61	46	39
	7,001-10,000	617	466	400	124	93	80	61	46	39
	10,001-20,000	627	471	404	125	94	80	61	46	39
	20,001-50,000	633	475	406	125	94	80	61	46	39
	50,001-100,000	635	476	407	125	94	80	61	46	39
	>100,000	637	476	407	125	94	80	61	46	39

If the sample size in the table exceeds the number of items on the vessel, then test ALL of the items.

Table II-7. Appropriate Sample Sizes when Number of Categories = 7

Number of Categories: 7

		1%			5%			10%		
	Conclusion Proportion	1%			5%			10%		
	Conclusion Probability	99%	95%	90%	99%	95%	90%	99%	95%	90%
Number of Items in 1 Material Category	1-30	ALL	ALL	ALL	ALL	27	26	26	24	22
	31-50	ALL	ALL	ALL	44	40	38	35	31	28
	51-75	ALL	ALL	74	60	53	49	40	33	30
	76-100	ALL	ALL	99	72	62	57	46	38	34
	101-200	192	183	176	94	77	68	54	42	37
	201-300	266	242	227	104	83	73	56	44	38
	301-400	322	283	261	110	86	75	58	45	39
	401-500	364	313	286	113	88	77	59	45	39
	501-600	397	336	304	115	89	78	59	46	39
	601-800	446	368	329	118	91	79	60	46	40
	801-1,000	479	389	345	120	92	80	61	46	40
	1,001-2,000	556	436	381	124	95	82	62	47	40
	2,001-3,000	586	454	395	125	95	82	62	47	41
	3,001-4,000	602	463	402	126	96	82	62	47	41
	4,001-5,000	611	469	406	127	96	83	62	47	41
	5,001-7,000	623	475	411	127	96	83	62	47	41
	7,001-10,000	631	480	414	127	96	83	62	47	41
	10,001-20,000	642	486	419	128	97	83	63	47	41
	20,001-50,000	648	490	421	128	97	83	63	47	41
	50,001-100,000	650	491	422	128	97	83	63	47	41
	>100,000	652	491	422	128	97	83	63	47	41

If the sample size in the table exceeds the number of items on the vessel, then test ALL of the items.

Table II-8. Appropriate Sample Sizes when Number of Categories = 8

Number of Categories: 8										
	Conclusion Proportion	1%			5%			10%		
	Conclusion Probability	99%	95%	90%	99%	95%	90%	99%	95%	90%
Number of Items in 1 Material Category	1-30	ALL	ALL	ALL	ALL	28	27	26	24	23
	31-50	ALL	ALL	ALL	44	40	38	36	31	28
	51-75	ALL	ALL	ALL	60	53	49	41	34	31
	76-100	ALL	ALL	99	73	63	58	47	38	34
	101-200	193	184	178	96	78	70	55	43	38
	201-300	267	244	230	106	85	75	57	45	39
	301-400	324	287	266	111	88	77	59	46	40
	401-500	368	318	291	115	90	79	60	46	40
	501-600	402	342	310	117	92	80	61	47	41
	601-800	452	375	336	121	93	81	61	47	41
	801-1,000	486	397	354	123	95	82	62	47	41
	1,001-2,000	566	447	392	127	97	84	63	48	42
	2,001-3,000	597	465	406	128	98	85	63	48	42
	3,001-4,000	613	475	414	129	98	85	63	48	42
	4,001-5,000	623	481	418	129	98	85	64	48	42
	5,001-7,000	635	488	423	130	99	85	64	48	42
	7,001-10,000	644	493	427	130	99	86	64	49	42
	10,001-20,000	655	499	432	130	99	86	64	49	42
	20,001-50,000	661	503	435	131	99	86	64	49	42
	50,001-100,000	663	504	436	131	99	86	64	49	42
	>100,000	665	504	436	131	99	86	64	49	42

If the sample size in the table exceeds the number of items on the vessel, then test ALL of the items.

Table II-9. Appropriate Sample Sizes when Number of Categories = 9

Number of Categories: 9

	Conclusion Proportion	1%			5%			10%		
	Conclusion Probability	99%	95%	90%	99%	95%	90%	99%	95%	90%
Number of Items in 1 Material Category	1-30	ALL	ALL	ALL	ALL	28	27	26	24	23
	31-50	ALL	ALL	ALL	44	41	39	36	31	29
	51-75	ALL	ALL	ALL	61	54	50	41	35	31
	76-100	ALL	ALL	99	73	64	59	48	39	35
	101-200	193	185	179	97	80	71	55	44	39
	201-300	269	247	233	107	86	76	58	46	40
	301-400	326	290	270	113	90	79	60	47	41
	401-500	371	322	296	117	92	81	61	47	41
	501-600	406	347	316	119	94	82	62	48	42
	601-800	457	381	343	123	96	84	62	48	42
	801-1,000	492	404	361	125	97	84	63	49	42
	1,001-2,000	574	456	402	129	99	86	64	49	43
	2,001-3,000	606	475	416	130	100	87	64	49	43
	3,001-4,000	623	485	424	131	100	87	65	49	43
	4,001-5,000	633	491	429	131	101	87	65	50	43
	5,001-7,000	646	499	434	132	101	88	65	50	43
	7,001-10,000	655	504	438	132	101	88	65	50	43
	10,001-20,000	666	511	443	133	101	88	65	50	43
	20,001-50,000	673	515	446	133	102	88	65	50	43
	50,001-100,000	675	516	447	133	102	88	65	50	43
	>100,000	677	516	447	133	102	88	65	50	43

If the sample size in the table exceeds the number of items on the vessel, then test ALL of the items.

Table II-10. Appropriate Sample Sizes when Number of Categories = 10

Number of Categories: 10

	Conclusion Proportion	1%			5%			10%		
	Conclusion Probability	99%	95%	90%	99%	95%	90%	99%	95%	90%
Number of Items in 1 Material Category	1-30	ALL	ALL	ALL	ALL	28	27	26	24	23
	31-50	ALL	ALL	ALL	45	41	39	36	32	29
	51-75	ALL	ALL	ALL	61	54	51	42	35	32
	76-100	ALL	ALL	ALL	74	65	59	48	40	36
	101-200	194	186	180	98	81	73	56	45	40
	201-300	270	248	235	109	88	78	59	47	41
	301-400	328	293	273	115	91	81	61	48	42
	401-500	373	326	300	118	94	83	62	48	42
	501-600	409	351	321	121	95	84	62	49	43
	601-800	461	386	349	124	97	85	63	49	43
	801-1,000	497	410	368	126	99	86	64	50	43
	1,001-2,000	582	464	410	131	101	88	65	50	44
	2,001-3,000	615	484	425	132	102	89	65	50	44
	3,001-4,000	632	494	433	133	102	89	66	50	44
	4,001-5,000	643	501	438	133	103	89	66	51	44
	5,001-7,000	655	508	444	134	103	90	66	51	44
	7,001-10,000	665	514	448	134	103	90	66	51	44
	10,001-20,000	676	521	453	135	104	90	66	51	44
	20,001-50,000	683	525	457	135	104	90	66	51	44
	50,001-100,000	685	526	458	135	104	90	66	51	44
	>100,000	688	526	458	135	104	90	66	51	44

If the sample size in the table exceeds the number of items on the vessel, then test ALL of the items.

Table II-11. Appropriate Sample Sizes when Number of Categories = 11

Number of Categories: 11										
	Conclusion Proportion	1%			5%			10%		
	Conclusion Probability	99%	95%	90%	99%	95%	90%	99%	95%	90%
Number of Items in 1 Material Category	1-30	ALL	ALL	ALL	ALL	28	27	27	25	23
	31-50	ALL	ALL	ALL	45	41	39	37	32	30
	51-75	ALL	ALL	ALL	61	55	51	42	36	32
	76-100	ALL	ALL	ALL	74	65	60	49	40	36
	101-200	194	187	181	99	82	74	57	45	40
	201-300	271	250	237	110	89	79	60	47	42
	301-400	330	296	276	116	93	82	62	48	43
	401-500	376	329	304	120	95	84	63	49	43
	501-600	412	355	325	122	97	85	63	49	43
	601-800	465	391	354	126	99	87	64	50	44
	801-1,000	502	415	374	128	100	88	65	50	44
	1,001-2,000	589	471	417	132	103	90	66	51	45
	2,001-3,000	622	492	433	134	104	91	66	51	45
	3,001-4,000	640	503	442	135	104	91	66	51	45
	4,001-5,000	651	509	447	135	105	91	67	51	45
	5,001-7,000	664	517	453	136	105	92	67	51	45
	7,001-10,000	673	523	457	136	105	92	67	52	45
	10,001-20,000	685	530	463	137	105	92	67	52	45
	20,001-50,000	692	534	466	137	106	92	67	52	45
	50,001-100,000	695	536	467	137	106	92	67	52	45
	>100,000	697	536	467	137	106	92	67	52	45

If the sample size in the table exceeds the number of items on the vessel, then test ALL of the items.

Table II-12. Appropriate Sample Sizes when Number of Categories = 12

Number of Categories: 12										
	Conclusion Proportion	1%			5%			10%		
	Conclusion Probability	99%	95%	90%	99%	95%	90%	99%	95%	90%
Number of Items in 1 Material Category	1-30	ALL	ALL	ALL	ALL	28	27	27	25	24
	31-50	ALL	ALL	ALL	45	42	40	37	32	30
	51-75	ALL	ALL	ALL	61	55	52	42	36	33
	76-100	ALL	ALL	ALL	75	66	61	49	41	37
	101-200	194	187	182	100	83	75	57	46	41
	201-300	271	251	239	111	90	81	61	48	43
	301-400	331	298	279	117	94	84	62	49	43
	401-500	378	332	307	121	97	86	63	50	44
	501-600	415	358	329	124	98	87	64	50	44
	601-800	469	396	359	127	100	89	65	51	45
	801-1,000	506	421	379	129	102	90	65	51	45
	1,001-2,000	595	478	424	134	104	92	67	52	45
	2,001-3,000	629	499	441	136	105	92	67	52	46
	3,001-4,000	647	510	450	136	106	93	67	52	46
	4,001-5,000	658	517	455	137	106	93	67	52	46
	5,001-7,000	671	525	461	137	107	93	67	52	46
	7,001-10,000	682	531	466	138	107	93	68	52	46
	10,001-20,000	694	538	471	138	107	94	68	52	46
	20,001-50,000	701	543	475	139	107	94	68	52	46
	50,001-100,000	703	544	476	139	107	94	68	53	46
	>100,000	706	544	476	139	107	94	68	53	46

If the sample size in the table exceeds the number of items on the vessel, then test ALL of the items.

Table II-13. Appropriate Sample Sizes when Number of Categories = 13

Number of Categories: 13

	Conclusion Proportion	1%			5%			10%		
	Conclusion Probability	99%	95%	90%	99%	95%	90%	99%	95%	90%
Number of Items in 1 Material Category	1-30	ALL	ALL	ALL	ALL	28	27	27	25	24
	31-50	ALL	ALL	ALL	45	42	40	37	33	30
	51-75	ALL	ALL	ALL	62	56	52	43	36	33
	76-100	ALL	ALL	ALL	75	66	61	49	41	37
	101-200	194	188	182	101	84	76	58	47	42
	201-300	272	253	240	112	91	82	61	49	43
	301-400	333	300	281	118	95	85	63	50	44
	401-500	380	335	310	122	98	87	64	50	45
	501-600	417	361	333	125	100	88	65	51	45
	601-800	472	400	364	129	102	90	66	52	45
	801-1,000	510	425	384	131	103	91	66	52	46
	1,001-2,000	600	484	430	135	106	93	67	53	46
	2,001-3,000	635	506	448	137	107	94	68	53	46
	3,001-4,000	654	517	457	138	107	94	68	53	46
	4,001-5,000	665	524	462	138	108	94	68	53	46
	5,001-7,000	679	532	468	139	108	95	68	53	47
	7,001-10,000	689	539	473	139	108	95	68	53	47
	10,001-20,000	701	546	479	140	109	95	68	53	47
	20,001-50,000	709	551	482	140	109	95	69	53	47
	50,001-100,000	711	552	484	140	109	95	69	53	47
	>100,000	714	552	484	140	109	95	69	53	47

If the sample size in the table exceeds the number of items on the vessel, then test ALL of the items.

Table II-14. Appropriate Sample Sizes when Number of Categories = 14

Number of Categories: 14										
	Conclusion Proportion	1%			5%			10%		
	Conclusion Probability	99%	95%	90%	99%	95%	90%	99%	95%	90%
Number of Items in 1 Material Category	1-30	ALL	ALL	ALL	29	28	27	27	25	24
	31-50	ALL	ALL	ALL	45	42	40	37	33	31
	51-75	ALL	ALL	ALL	62	56	53	43	37	33
	76-100	ALL	ALL	ALL	75	67	62	50	42	38
	101-200	195	188	183	101	85	77	58	47	42
	201-300	273	254	242	113	92	83	62	49	44
	301-400	334	302	283	119	96	86	63	50	45
	401-500	382	337	313	123	99	88	65	51	45
	501-600	419	364	336	126	101	89	65	52	46
	601-800	475	403	368	130	103	91	66	52	46
	801-1,000	514	429	389	132	104	92	67	53	46
	1,001-2,000	605	489	436	137	107	95	68	53	47
	2,001-3,000	641	512	454	138	108	95	68	53	47
	3,001-4,000	660	524	463	139	109	96	69	54	47
	4,001-5,000	672	531	469	140	109	96	69	54	47
	5,001-7,000	685	539	475	140	109	96	69	54	47
	7,001-10,000	696	546	480	141	110	96	69	54	47
	10,001-20,000	708	553	486	141	110	97	69	54	47
	20,001-50,000	716	558	490	142	110	97	69	54	47
	50,001-100,000	719	560	491	142	110	97	69	54	47
	>100,000	721	560	491	142	110	97	69	54	47

If the sample size in the table exceeds the number of items on the vessel, then test ALL of the items.